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# AMERICAN STREET RAILWAYS:

THEIR

# CONSTRUCTION, EQUIPMENT

AND

# MAINTENANCE.

BY

AUGUSTINE W. WRIGHT,
CONSULTING ENGINEER.
MEMBER AMERICAN SOCIETY CIVIL ENGINEERS;
MEMBER WESTERN SOCIETY ENGINEERS.

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# DEDICATION.

To V. C. Turner, Esq.,

Late President North Chicago City Railway.

My Dear Mr. Turner: I take the liberty of dedicating to you the following pages, as a slight evidence of my appreciation of the kind advice and counsel with which you favored me during the entire term of my service with the North Chicago City Railway; as a token of regard for your worth as an individual and as a railway manager.

Sincerely, your friend,

Augustine W. Wright.

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# PREFACE.

The following pages were written from time to time, as moments could be taken from a busy professional life. They were gathered together, and, having appeared in the columns of the *Street Railway Gazette*, are now offered in book form, to meet a want evinced by those who have endeavored to obtain information upon these subjects.

My apology for issuing the book is that no one during the past twenty-five years has written upon this subject in the United States. The able work, "Tramways," from the well-known pen of D. K. Clark, treats of construction as practiced in Great Britain and upon the continent; which differs as widely from American construction as do the Steam Railway Systems of those countries. Having had nearly twelve years' experience upon Steam Roads, I served almost eight years as Chief Engineer, Superintendent of Track and Construction of the North Chicago City Railway, with the rare advantage of being under V. C. Turner, President, by whose able management the capital stock of that Company was advanced from $75 to $635 dollars per share.

Mr. Turner, during the twenty-seven years of his connection with that Company, in various positions, accumulated a fund of information that included every detail of Street Railway management. To his kind advice I ascribe any success I may have achieved.

Upon January 1st, 1887, it appeared from the best attainable information that there were 4,864 miles of street railway in the United States, upon which 20,392 cars were drawn, and 98,659 horses were employed, besides cables, etc. These roads are increasing yearly in number and in value, and it is hoped that the following pages may not be without benefit to their management.

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# AMERICAN STREET RAILWAYS.

## CHAPTER I.

## TRACK CONSTRUCTION.

### INTRODUCTORY.

The amount of capital invested in the street railways of this country is measured by tens of millions! Each street railroad official is endeavoring to get the *best* for the least money. The requirements for the different roads vary with the surroundings.

A track constructed in the busy streets of a great metropolis, having to carry, in addition to its own great traffic, a large portion of the general business of the city, should be built in a more substantial manner than the track in the street of a village where the traffic is proportionately less.

Few people, outside of the street railway officials, realize to what extent general traffic seeks the smooth way afforded by the rails, with lessened friction. On April 14th, 1881, I stationed a man with pencil and paper on North Clark street (in Chicago), between Elm and Division streets, for ten hours, from 7 a.m. until 12 m. and from 1 p.m. until 6. p.m., with directions to carefully count every vehicle that passed, and note those whose wheels traveled upon the horse railroad rails, those which used the sixteen feet of pavement the company has to maintain, without being on the rail, and those who traveled entirely outside the sixteen feet above mentioned. He reported 2,052 vehicles upon the rails (including 642 cars), 61 vehicles upon the aforementioned sixteen feet, but not on the rails, and 53 outside; 97.6 per cent of the street traffic at this time and place sought the railroad, and the street was paved with pine blocks from curb to curb. On Lincoln avenue, near Webster avenue, he found 87½ per cent., and in front of Lincoln Park, 90 per cent. of the total street traffic sought the sixteen feet maintained by the street railway company.

These figures should convince the reader that street railroad tracks must not be designed and constructed to carry the street railway traffic alone. I am clearly of the opinion, also, that no dependence must be placed upon the adjoining pavements to support the tracks. Frequently, holes are dug alongside the track, the street pavement is allowed to remain long after it is worn out, and ruts are permitted to remain adjacent to the rail, caused by vehicles attempting to get onto the rail, but traveling with the wheels outside of the rail. That it is poor economy to allow the pavements to get into such a condition can not be controverted, but the fact remains, nevertheless, that only too often this is the case.

## THE CROSS-TIE.

Beginning at the bottom of our track, we will first consider the cross-tie. I am aware that occasionally a street railroad is constructed without cross-ties, but I question the ultimate economy. Iron ties are used to such a limited extent in this country that it is hardly worth while to discuss the substitution of iron for wood. The first point to be considered in the selection of a cross-tie is the kind of wood. The variety to be adopted will depend upon the relative durability and first cost chiefly. The durability of timber buried under ground, from which air is excluded, is measured by centuries. Street railroad cross-ties are not deep enough in the ground not to be affected by the air and alternate moisture and dryness. It is difficult to obtain authentic statistics of the durability of different woods and the same kind of wood in different soils.

I extract the following from the report of the A. S. R'y Association, third annual meeting:

Mr. Clemenshaw, of Troy, stated that Georgia pine ties were apparently as good as when put in the track, after twenty-one years. Mr. Hazard stated that he used yellow pine exclusively for stringer, 5x7 inches, and chestnut or oak tie seven feet long, 6x8 inches. Used knees on both sides, and laid only centre bearing rail of fifty or sixty pounds per yard.

Wm. Wharton, Jr., considered good, heavy, substantial yellow pine stringers the best, and centre bearing steel rail fifty or sixty lbs. per yard.

Charles Hathaway considered white pine the best material for stringers, having lasted twenty years in Pittsburgh.

T. J. Minary, of Louisville, used oak, and considered its life as from ten to twenty years.

In an investigation by F. B. Hough, for the Department of Agriculture, upon the durability of steam railway cross-ties, it appears "The relative importance of the various kinds of timber for railway purposes are reported in the following order: Oaks, pines, chestnut, hemlock, cedars, tamarack, cypress, elms, ash, cherry, black walnut, firs, spruce, beech, locust, redwood, maple, butternut, coffeenut, mulberry and mosquit."

The following table gives the average durability and cost of cross-ties to steam railroads, by Mr. Hough:

TABLE OF DURABILITY AND COST OF CROSS TIES.

| KIND OF TIMBER. | AVERAGE. | |
|---|---|---|
| | Durability in Years. | Cost. |
| Oak | 7.4 | $0 41.2 |
| White Oak | 7.3 | 40.6 |
| Post “ | 7.0 | 33.0 |
| Burr “ | 7.4 | 37.3 |
| Rock “ | 7.0 | 42.0 |
| Red “ | 5.0 | 27.0 |
| Chestnut “ | 7.1 | 28.0 |
| Black “ | 4.5 | 43.0 |
| Southern Pine | 6.5 | 37.0 |
| White “ | 6.5 | 31.5 |
| Cedar, Red | 11.8 | 34.0 |
| “ White | 7.5 | |
| Cypress | 8.7 | |
| Ash, White | 4.3 | |
| “ Black | 3.8 | |
| Cherry | 6 to 10 | |

The *Railroad Gazette*, December 26th, 1884, contains a valuable editorial upon the standard dimensions and woods of American (steam railroad) cross-ties, in which it appears that the following percentage of the various woods is used upon 90,900 miles out of 121,592 miles in operation:

| | | |
|---|---|---|
| White Oak | 58.2 | per cent. |
| Cedar | 10.4 | “ |
| Yellow Pine | 8.7 | “ |
| Northern Pine | 6.9 | “ |
| Hemlock | 5.9 | “ |
| Chestnut | 4.4 | “ |
| Fir | 1.7 | “ |
| Spruce | 1.6 | “ |
| Cypress | 1.0 | “ |
| Miscellaneous Soft Woods | 0.6 | “ |
| Miscellaneous Hard Woods | 0.6 | “ |
| Total | 100 | “ |

The durability of the same kind of timber varies.

1st. With the age of the tree. "The life of trees, like that of man, has been commonly divided into three stages—infancy, maturity and old age. In the first the tree increases from day to day; in the second it maintains itself without sensible gain or loss; but in the third it declines. These stages vary in every species according to the soil, the aspect, the climate, or the nature of the individual plant."

2d. With the time of year in which the tree is cut. It is generally conceded that the decay of timber is caused by the fermentation of the sap. The tree should, therefore, be felled when it contains the least sap.

3d. The timber should be seasoned before it is used. Air seasoning under a roof is the best. As a rule, my stringers and ties are piled up so that the air has free circulation about them for two years or over. Water seasoning in a running stream has been recommended from the time of Evelyn and Pepys. "The natural juices of the tree are removed by the water penetrating throughout its pores."

4th. The soil in which the tree grows affects its durability. Wood grown in a moist soil is lighter and decays sooner than that grown in dry, sandy soil. Its structure is not so compact and it contains more moisture.

The cross-tie of a street railroad has quite a different duty to perform from that of a steam railroad. In the street railroad the tie is not subjected to wear, as it is under the rail of a steam railroad. It is not so subject to decay, being protected by the pavement from the weather. It serves to support the track, and when angle irons are used, to hold the rails and stringers to gauge. I use cedar cross-ties, costing, this season, in Chicago, 27 cents each. My specifications are: Ties to be of sound cedar, sawed to eight feet in length, six inches deep, and not less than six inches face, sawed on top and bottom.

Sawed ties are considered objectionable upon many steam railroads, being thought not so durable, and they are not as strong; but in street railway tracks it is important to have a smooth, level surface on the cross-tie to take the stringer and give it a perfect bearing. I experienced so much difficulty in obtaining ties hewed true and level, that I have adopted sawed in place of hewn ties. The ties should, so far as possible, have equal widths, except that they should be wider under the stringer joint, so that the support given the track may be as uniform as possible. Unequal widths would cause unequal settlement of the track.

The greatest weight of a car and its load upon horse railroads probably never exceeds twelve tons, and this would be distributed by the stringer over three cross-ties, or, say, four tons per each tie, but this may be exceeded in cities by heavy loads of machinery, etc., seeking the lessened resistance afforded by the tram rails. If the cross-tie be eight inches broad and eight feet long, it would afford 5⅓ square feet of bearing surface, and in the case of the above load of four tons, would have to carry 1,500 lbs. per square foot. My practice is to space my cross-ties four feet between centres. When plank is used outside of the track and along it, twelve and sixteen foot planks fit without waste, and stringers may be a multiple of four feet. I select the widest ties to put under the stringer joints.

Pine ties that had been under my tracks ten years appeared as sound and bright as the day they were put in, and I relaid track upon them. Cedar ties show no sign of decay after a like service. When the track is held to gauge with angle irons, or knees, as they are usually termed, the question of hardness of the wood in the cross-tie may be considered, as the harder the wood, the better it holds the spikes driven into it.

## ADHESION OF VARIOUS NAILS, SPIKES AND SCREWS IN DIFFERENT WOODS.

The importance of the above subject, and the comparative dearth of knowledge in print relating thereto, led to my making some experiments.

I used a Tee rail as a lever, turning on an iron pin as a fulcrum, giving little friction.

The cedar used was a portion of a cross-tie eight inches wide, six inches deep. It had been felled about eighteen months. Fresh spikes were used for each test, as I found that the spike "held" much less when used twice, or more times.

Record of tests of force in pounds required to draw the following sized spikes out of a cedar cross-tie seasoned eighteen months. Spikes wedge pointed and driven across the grain of the wood:—

| SIZE OF SPIKE — INCHES. | Distance Driven into the Wood. | Force exerted in pounds to draw the spikes. | | | | | | | | Average Force in Pounds. |
|---|---|---|---|---|---|---|---|---|---|---|
| ¼x¼x5 | 4¼ in. | 884 | 1159 | 766 | 766 | 805 | 766 | | | 857 4-6 |
| ¼x¼x6. | 5 in. | 785 | 884 | 923 | 805 | 766 | 766 | | | 821 3-6 |
| ½x½x6. | 5 in. | 2159 | 1946 | 1379 | 2026 | 1120 | 1521 | | | 1,691 5-6 |
| ⅜x⅜x5. | 4¼ in. | 687 | 1002 | 1556 | 1159 | 1080 | 1379 | 1379 | 1379 | 1,202 5·8 |

The large amount in the second test of the ¼x¼x5 in. spike was caused by its being driven into a knot. Ignoring this one test for that reason, the average force required to extract that size of spike was 797 2-5 lbs.; second, 821 3-6 lbs.; third, 1,691 5-6 lbs.; fourth, 1,195 5-8 lbs. The respective resistances per square inch of spike surface driven into the wood were 187.6 lbs., 164.3 lbs., 169.18 lbs. and 188.64 lbs. The average of which is 177.4 lbs. per square inch.

Other experiments that I find in engineering literature upon this subject are as follows:

Trautwine, in his Engineers' Pocket Book, p. 383, speaking of the adhesion of spikes, says: "Professor W. R. Johnson found that a plain spike, .375 or 3/8 inches square, driven 3 3/8 inches into seasoned Jersey yellow pine or unseasoned chestnut, required about 2,000 pounds force to extract it; from seasoned white oak, about 4,000 pounds; and from well seasoned locust, 6,000 pounds.

"Recent careful experiments in Hanover, Germany, by Engineer Funk, give from 2,465 to 3,940 lbs. (mean of many experiments, about 3,000 lbs.) as the force necessary to extract a plain, one-half square inch iron spike, six inches long, wedge pointed for one inch (twice the thickness of the spike) and driven 4½ inches into white or yellow pine. When driven five inches, the force required was about one-tenth part greater. Similar spikes, nine-sixteenth inches square, seven inches long, driven six inches deep, required from 3,700 to 6,745 pounds to extract them from pine, the mean of the results being 4,873 pounds. In all *cases about twice as much force* was required to extract them from oak. The spikes were all driven *across* the grain of the wood. Experience shows that when driven *with* the grain, spikes or nails do not hold with more than half as much force.

"Jagged spikes or twisted ones (like an auger) or those which were either swelled or diminished near the middle of their length, all proved inferior to plain, square ones. When the length of the wedge point was increased to four times the thickness of the spike, the resistance to drawing out was a trifle less. When the length of the spike is fixed, there is probably no better shape than the plain, square cross section, with a wedge point twice as long as the width of the spike.

"Boards of oak or pine nailed together by from four to sixteen tenpenny common cut nails, and then pulled apart in a direction lengthwise of the boards and across the nails, tending to break the latter in two by a shearing action, averaged about 300 to 400 lbs. per nail to separate them, as the result of many trials."

Tredgold, in his "Principles of Carpentry," fifth edition, p. 189, article "Nails," says: "Nails are, in fact, pins made of iron, and the resistance they offer to being drawn is very considerable."

The following abstract of Mr. Bevan's experiments exhibits the relative adhesion of nails of various kinds when forced into dry Christiana deal, at right angles to the grain of the wood:

| KIND OF NAILS | Number to the pound, avoirdupois. | Inches long. | Inches forced into the wood | Powers required to extract. |
|---|---|---|---|---|
| Fine Sprigs | 4,560 | 0.44 | 0.4 | 2 |
| Fine Sprigs | 3,200 | 0.53 | 0.44 | 37 |
| Threepenny Brads | 618 | 1.25 | 0.50 | 58 |
| Cast iron Nails | 380 | 1.00 | 0.50 | 72 |
| Sixpenny Nails | 73 | 2.50 | 1.00 | 187 |
| Sixpenny Nails | 73 | 2.50 | 1.50 | 327 |
| Sixpenny Nails | 73 | 2.50 | 2.00 | 530 |
| Fivepenny Nails | 139 | 2.00 | 1.50 | 320 |

| Weight in pounds required to draw a sixpenny nail driven in one inch into the below mentioned wood. Last column the amount of force in pounds. | Pounds. |
|---|---|
| Dry Christiana Deal | 187 |
| Dry Oak | 507 |
| Dry Elm | 327 |
| Dry Beech | 667 |
| Green Sycamore | 312 |
| Dry Christiana Deal, driven in endways | 87 |
| Dry Elm, driven in endways | 257 |
| (Thin sixpenny nails, at 73 to the pound.) | |

It was further desirable to ascertain the degree of dependence that might be placed on nailing two pieces together, and Mr. Bevan kindly undertook to make some trials. Two pieces of Christiana deal, seven-eighths of an inch thick, were nailed together with two six-penny nails, and a longitudinal force in the plane of the joint, and consequently at right angles to the direction of the nails, was applied to cause the joint to slide; it required a force of 712 lbs., and the time was fifteen minutes; the nails curved a little and were then drawn.

"Another experiment was made in the same manner with dry oak, an inch thick, in which the force required was 1,009 lbs.; the six-penny nails curved and were drawn by that force.

"Dry, sound ash, an inch thick, joined in the same manner by two six-penny nails, bore 1,220 pounds thirty minutes without sensibly yielding; but when the stress was increased to 1,420 pounds, the pieces separated with an easy and gradual slide, curving and drawing the nails same as before, one of which broke."

Rankin, in his "Civil Engineering," p. 460, quotes the above, and says: "So far as these results can be expressed by a general law they seem to indicate that the force required to draw a nail driven across the grain of a given sort of wood varies nearly as the *cube of the square root of the depth to which it is driven*, and that it increases with the diameter of the nail, but in a manner that has not yet been expressed by a mathematical law."

The following table gives the results of tests made by Arthur M. Wellington, C. E., conducted as follows: The test blocks were reduced to a uniform thickness of four and a quarter inches, this thickness being just sufficient to give a full bearing to the *parallel* sides of the spike when driven to the usual depth, and allow the point of the spike to project outwards. It was considered that the beveled point could add very little to the holding power of the spike, and it was desired to press the spike out again by direct pressure after turning the block over. The force was applied by a loaded lever, an iron bar fourteen feet long and 1½x4 inches section, the fulcrum being at one end and the spike to be driven or expelled, placed two feet from it. A fulcrum was obtained by a mortise in the frame of the shop. An apparatus of this form works well in every respect.

Table showing tests of various woods for resistance to driving and pulling spikes treated and untreated by the Thilmeny (Sulphate of Baryta) process. All test pieces of the same kind of wood were cut from the same stick. All the woods, except as specified, had been cut six or eight months, and were partially seasoned. Spikes used for tests were of standard size and form, viz.: 5½x$\frac{9}{16}$. Thickness of blocks, 4¼ inches.

| Kind of wood in order of resistance to extracting spike. | Actual resistance in pounds. | | | | | | | | | | Realtive resist'nce (av. b'th prp'd & unprp'd t'king force toext'ct spk from green oak (6523) as 1. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Natural wood untreated. | | | | Prepared wood. | | | | Av. both prep'd & unprep'd | | | |
| | To driving spike. | | To pulling spike. | | To driving spike. | | To pulling spike. | | To dvg spk. | To pl'g spk. | To drv'g spike | To pul'g spike |
| Beech | 5216<br>6743 | 5979 | 5673<br>6282 | 5978 | 7288<br>7656 | 7472 | 8873<br>8267 | 8420 | 7107 | 7199 | 1.085 | 1.10 |
| White oak (green) | 5970<br>5670 | 5820 | 7179<br>5869 | 6523 | .......... | | .......... | | 5820 | 6523 | 0.89 | 1.00 |
| Pin oak | 5216<br>5521 | 5368 | 6638<br>6469 | 6553 | 6117<br>4589 | 5353 | 6135<br>6267 | 6201 | 5360 | 6377 | 0.815 | 0.975 |
| White ash | 5953 | 5953 | 4560 | 4560 | 6588<br>5978 | 6283 | (Split.) | | 6118 | 4560 | 0.935 | 0.75 |
| White cak well seasoned | 6433<br>6433 | 6433 | 5128<br>3435 | 4281 | .......... | | .......... | | 6433 | 4281 | 0.98 | 0.65 |
| Black ash | 3996<br>4202 | 4099 | 4408<br>4868 | 4638 | 4453<br>4453<br>4301<br>3380 | 4147 | 3340<br>3028<br>3300<br>3493 | 3290 | 4123 | 3964 | 0.63 | 0.605 |
| Elm | 4453<br>4758 | 4606 | 3535<br>3843 | 3690 | 4453<br>4148 | 4300 | 4148<br>4200 | 4175 | 4453 | 3932 | 0.68 | 0.600 |
| Chestnut (green) | 3996<br>3386 | 3691 | 2730<br>3790 | 3260 | .......... | | .......... | | 3691 | 3260 | 0.56 | 0.50 |
| Soft maple | 4148<br>3538 | 3843 | 2578<br>3645 | 3111 | 3843<br>3448 | 3645 | 2725<br>3030 | 2877 | 3744 | 2994 | 0.575 | 0.46 |
| Sycamore | 4103<br>3493 | 3798 | 3188<br>3188 | 3188 | 3691<br>3976 | 3833 | 1968 | 1968 | 3815 | 2578 | 0.585 | 0.395 |
| Hemlock | 2910 | 2910 | 1996 | 1996 | .......... | | .......... | | 2910 | 1996 | 0.44 | 0.30 |

It will be noticed that Mr. Wellington found the force required to draw spikes $\frac{9}{16}$x$\frac{9}{16}$ inches, driven 4¼ inches into seasoned oak, to be 4,281 pounds. Same spikes, etc., in unseasoned oak, 6,523 pounds. Funk gave as the result of many experiments with spikes ½x½ inch, driven 4½ inches into yellow pine, 3,000 pounds, and twice this amount, or 6,000, for oak. If his experiment was with unseasoned oak, these tests do not differ materially.

Some of the deductions drawn by Wellington from the above experiments are as follows:

" A beach tie, if effectually preserved from rotting, would be a better tie than white oak, and a red or pin oak tie about as good. Elm, black and white ash, if effectually preserved, will hold a spike about two-thirds as well as beech or oak, and about one-third better than chestnut. Soft maple and sycamore hold a spike about four-fifths as well as chestnut, about two-fifths as well as oak or beech, and about one-half better than hemlock. Seasoned white oak is about one-third less effective than green timber in holding a spike. The force required to drive a spike and to pull it out are as nearly as may be equal with hard woods, it being often the case that considerably more dead load is required to push out the spike than to drive it in. On the other hand, with the softer woods the force required to drive the spike is about one-fifth greater. It is a peculiarity which may be frequently noticed in this table that a spike which has required a greater force than another to drive it into the same wood will require less force to drive it out, and *vice versa*. No difference could be discovered to push out a spike on account of the difference in time that the spike had been driven. Some of the spikes were pushed out immediately, some left in several hours. some were left in over night; but no difference on that account could be discovered."

Regarding screws, Tredgold, p. 190, says: "The adoption of screws instead of common nails is a considerable improvement. The following experiments on the force necessary to draw screws of iron, commonly called wood screws, out of given depths of wood, were made by Mr. Bevan. The screws he used were about two inches in length, $\frac{22}{100}$ diameter at the exterior of the threads, $\frac{15}{100}$ diameter at the bottom; the depth of the worm or thread being $\frac{35}{1000}$, and the number of threads in one inch, 12. They were passed through pieces of wood exactly half an inch in thickness, and drawn out by the weights stated in the following table:

| | | |
|---|---|---|
| Dry beech | 460 | pounds. |
| Dry beech | 790 | " |
| Dry, sound ash | 790 | " |
| Dry oak | 760 | " |
| Dry mahogany | 770 | " |
| Dry elm | 665 | " |
| Dry sycamore | 830 | " |

The weights were supported about two minutes before the screws were extracted. He found the force required to draw similar screws out of deal and the softer woods about half the above. The force necessary to cause pieces screwed together to slide at the joining was also determined; the pieces being joined by two screws; the resultant of the force coinciding with the plane of the joint, and in line with the plane of the screws. With Christiana deal, seven-eighths of an inch thick, joined by two screws, one and five-eighths of an inch in length and five-fortieths of an inch in diameter within the worm, a load of 1,009 pounds gradually applied broke both the screws at the line of joint, after elongating the interior of the hole and sliding about six-tenths.

With very dry, seasoned oak, one inch thick, two screws, 1⅝ long and $\frac{6}{40}$ diameter within the thread, bore 1,009 lbs. for ten minutes without any signs of yielding; with 1,137 lbs. both screws broke in two places, each screw about $\frac{2}{10}$ of an inch within each piece of wood; the holes were a little elongated.

With dry and sound ash, one inch thick, with screws 2¼ inches long, passing ¼ of an inch through one of the pieces, the diameter at bottom of the worm $\frac{7}{40}$; the load begun with was 1,224 pounds, gradually increased for two hours to 2,661 pounds; this produced a slow and moderate sliding, not separation, the screws being neither drawn nor broken, but probably would have been if not removed on account of night coming on, and putting an end to the experiment."

In the tests detailed in tables one, two and three, I used the same lever, but instead of spring balances, attached a box into which I put weights of iron until the screws were pulled and then ascertained the weight on Fairbanks scales. Table "one:" Taking dry white ash as a standard, these tests tend to show that with the same sized screw, black walnut requires nearly the same power to extract the screw. A closer grained dry white ash required 1.08 times this power; dry red oak, 1.35; dry Georgia pine, 1.06; dry Norway pine, 0.60. In each one of these tests, I bored a hole the size of the shaft of the screw. A test of the same screw *driven* into dry Norway pine (the same piece of timber), without boring, was extracted by 0.35 of the power required for dry ash, or about ½ of the power required when the screw was *screwed* into a bored hole in the same stick. This proves the mistake made by many carpenters who drive a screw nearly home. Table "two" gives the power required to extract various sizes of screws from the same wood, the last column containing the per centages taking a 1½-inch screw No. 10 as 1.00 Table "three" contains tests of the power required to extract "drive" screws as made by Shumway, Burgess & Co. *driven* into the wood, ordinary "lag" screws screwed into the wood, and spikes ½ inch square driven into the wood, across the grain. As they were of different lengths, it is not possible to compare them, except in the case of the spikes and the 5-inch drive screw. This was 1.25 per cent., or ¼ more power to extract the drive screw than the spike. The 4 inch gave 1.25 and 1.59. The latter amount would tend to show the advantage of a double thread over a single thread. Pieces taken from the same stick of timber were used for all the tests in this table.

Comparative resistance of the following woods to the extraction of screws three inches long, No. 16, with nine threads to the inch. Screwed 2½ inches into the wood. Manufactured by the Russell & Erwin Company.

### TABLE ONE.

| Kind of Wood. | Weight on End of Lever. | Resulting Power in Pounds | Pounds Exerted by Weight of Lever. | Total number of Pounds required to pull the Screw | Average for Each Wood. | Relative Resistance taking Dry Ash 2424 as 1.00 |
|---|---|---|---|---|---|---|
| * Norway Pine Seasoned 18 mos | 100 | 1500 | 10 | 1500 | | |
| | 95 | 1425 | 0 | 1425 | 1475 | |
| | 100 | 1500 | 0 | 1500 | | 0 60 |
| †Dry Black Walnut. | 53 | 470 | 1379 | 1849 | | |
| | 43 | 593 | 2245 | 2838 | 2439 | 1.00 |
| | 28 | 386 | 2245 | 2631 | | |
| ††Dry Red Oak. | 90 | 1241 | 2245 | 3486 | | 1.35 |
| | 68 | 938 | 2245 | 3183 | 3284 | |
| | 68 | 938 | 2245 | 3183 | | |
| ‡Dry White Ash. | 13 | 179 | 2245 | 2424 | 2424 | 1 00 |
| | 13 | 179 | 2245 | 2424 | | |
| | 28 | 386 | 2245 | 2631 | 2631 | 1.08 |
| ‡‡Dry Hard Pine. | 13 | 179 | 2245 | 2424 | | |
| | 39 | 538 | 2245 | 2783 | 2580 | 1.06 |
| | 21 | 289 | 2245 | 2534 | | |
| §Norway Pine Seasoned 18 mos. | 108 | 531 | 687 | 1218 | | |
| | 13 | 64 | 687 | 751 | | |
| | 13 | 64 | 687 | 751 | 859 | 0.35 |
| | 13 | 64 | 687 | 751 | | |
| | 50 | 246 | 687 | 933 | | |
| | 13 | 64 | 687 | 761 | | |

*This is a pine from Northern Michigan, and is used by us for track stringers.

†Broke head of one screw.

††Broke heads of two screws.

‡Two samples of Dry White Ash, one fine grained and the other a coarser grain. The larger amount is test of the former, the other two of latter.

‡‡This is Southern Pine.

§Screw driven into the wood without having any hole bored.

## TABLE TWO.

Tests of the power in pounds required to extract the following different sizes of screws from the above samples of coarser grained dry, white ash, fine grain dry white ash and dry black walnut:

| LENGTH. | | NUMBER | | Distance screwed into wood. | Weight on lever in pounds. | Resulting power in pounds. | Power exerted by weight upon lever. | Total power required to pull the screws in pounds. | Average for each screw. | Relative resistances taking resistance of 1½ in. scewr 943 as 1. |
|---|---|---|---|---|---|---|---|---|---|---|
| Of screw in inches. | Of thread on screw. | Common number of screw. | Threads to 1 inch. | | | | | | | |
| 3 in. | 1¾ | 20 | 8 | 2½ | 38 | 524 | 2245 | 2769 | *2886 | 3.06 |
| | | | | | 55 | 758 | 2245 | 3003 | | |
| | | | | | 13 | 179 | 2245 | 2424 | †2424 | 2.57 |
| 3 in. | 1¾ | 20 | 8 | 2½ | 45 | 620 | 2245 | 2865 | 2879 | 3.05 |
| | | | | | 50 | 690 | 2245 | 2935 | | |
| | | | | | 43 | 593 | 2245 | 2838 | | |
| 2½ in. | 1¾ | 16 | 9 | 2 | 13 | 141 | 1725 | 1866 | §1857 | 1.97 |
| | | | | | 55 | 487 | 1379 | 1866 | | |
| | | | | | 52 | 461 | 1379 | 1840 | | |
| 2½ in. | 1¾ | 14 | 10 | 2 | 52 | 461 | 1379 | 1840 | §1813 | 1.92 |
| | | | | | 36 | 319 | 1379 | 1698 | | |
| | | | | | 59 | 523 | 1379 | 1902 | | |
| 2 in. | 1¾ | 20 | 8 | 1½ | 28 | 248 | 1379 | 1627 | §1586 | 1.69 |
| | | | | | 29 | 257 | 1379 | 1636 | | |
| | | | | | 13 | 115 | 1379 | 1494 | | |
| 2 in. | 1¼ | 16 | 9 | 1½ | 13 | 115 | 1379 | 1494 | §1633 | 1 73 |
| | | | | | 45 | 399 | 1379 | 1778 | | |
| | | | | | 28 | 248 | 1379 | 1627 | | |
| 2 in. | 1¼ | 14 | 10 | 1½ | 24 | 213 | 1379 | 1592 | §1580 | 1 67 |
| | | | | | 21 | 186 | 1379 | 1565 | | |
| | | | | | 23 | 204 | 1379 | 1583 | | |
| 2 in. | 1¼ | 12 | 12 | 1½ | 23 | 204 | 1379 | 1583 | §1549 | 1.64 |
| | | | | | 21½ | 190 | 1379 | 1569 | | |
| | | | | | 13 | 115 | 1379 | 1494 | | |
| 1½ in. | ⅞ | 16 | 9 | 1 | 90 | 442 | 687 | 1129 | §1142 | 1.21 |
| | | | | | 95 | 467 | 687 | 1154 | | |
| 1½ in. | ⅞ | 14 | 10 | 1 | 104 | 511 | 687 | 1198 | §1185 | 1.25 |
| | | | | | 100 | 492 | 687 | 1174 | | |
| | | | | | 100 | 492 | 687 | 1179 | | |
| 1½ in. | ⅞ | 10 | 13 | 1 | 28 | 138 | 687 | 825 | §943 | 1.00 |
| | | | | | 69 | 339 | 687 | 1026 | | |
| | | | | | 59 | 290 | 687 | 977 | | |

* Fine grain dry white ash.
† Coarse grain dry white ash.
‡ Black walnut.
§ Coarse grain dry white ash.

### TABLE THREE.

Tests of power required to draw the following screws out of Norway pine seasoned eighteen months:

| Description of screw. | | Length of thread inches. | Distance in Wood, inches. | Weight on lever in pounds. | Resulting power in pounds. | Power exerted by weight of lever. | Total power required to pull the screw in pounds. | Average for each screw. | Percentage of power taking spike 2191=1.00 |
|---|---|---|---|---|---|---|---|---|---|
| One-half in. diam. | Shumway-Burgess Co. Mfr. | | | | | | | | * |
| drive screw..... | | 3 | 4 | 13 | 179 | 2245 | 2424 | 2424 | 1.10 |
| 4 threads to 1 inch | | 0 | 0 | 0 | 0 | 2245 | 0 | 0 | † |
| " " " | | 3 | 5 | 74 | 1020 | 2245 | 3265 | | |
| " " " | | 3 | 5 | 27 | 496 | 2245 | 2741 | | †† |
| " " " | | 3 | 5 | 27 | 496 | 2245 | 2741 | 2743 | 1.25†† |
| " " " | | 3 | 5 | 13 | 239 | 2245 | 2484 | | †† |
| " " " | | 3 | 5 | 13 | 239 | 2245 | 2484 | | †† |
| D'ble thr'd 3 to 1 in | | | | 79½ | 1096 | 2245 | 3341 | | |
| " 3 " 1 " | | 3¾ | 4 | 13 | 179 | 2245 | 2424 | 2730 | 1.25 |
| " 3 " 1 " | | 3¾ | 4 | 13 | 179 | 2245 | 2424 | | ‡ |
| " 3 " 1 " | | 3 | 4 | 74 | 1020 | 2245 | 3265 | | |
| " 3 " 1 " | | 3 | 4 | 125 | 1724 | 2245 | 3969 | 3477 | 1.59 |
| " 3 " 1 " | | 3 | 4 | 69 | 952 | 2245 | 3197 | | |
| Lag scr'w thr'd 7 to 1 in | | 2 | 1½ | 13 | 115 | 1379 | 1494 | | ‡‡ |
| " " 7 " 1 " | | 2 | 1½ | 126 | 619 | 687 | 1306 | 1465 | 0 67 |
| " " 7 " 1 " | | 2 | 1½ | 185 | 909 | 687 | 1596 | | ‡‡ |
| " " 6 " 1 " | | 2 | 2½ | 179 | 880 | 687 | 1567 | | § |
| " " 6 " 1 " | | 2 | 2½ | 79 | 700 | 1379 | 2079 | 2206 | 0.92 |
| " " 6 " 1 " | | 2 | 2½ | 119 | 1054 | 1379 | 2433 | | \| |
| Horse R.R. spike one-half square ........ | | | 5 | 82 | 727 | 1379 | 2106 | | 1.00 |
| | | | 5 | 95 | 842 | 1379 | 2221 | 2191 | |
| | | | 5 | 98 | 868 | 1379 | 2247 | | |

*Screws driven into wood.
†Pulled head off screw.
††Leverage 1.5 feet.
‡Pulled head off screw.
‡‡Lag screws screwed into wood with a wrench, without boring.
§Hole bored 5-16 diameter.
|Screwed into wood with a wrench.

I am kindly permitted by Rust & Coolidge to include in this paper the following tests made by them to ascertain the relative force required to extract square and round iron drift bolts from white and Norway pine, from which it ap-

### TABLE FOUR.

Report of tests made May 29th, 1878, for H. S. Dale, on resistance of drift bolts in timber.

| | | | | | | | RESISTANCE. |
|---|---|---|---|---|---|---|---|
| 1st test, | 1 in. | square iron, | driven | 30 ins. | in white pine, | 15-16 hole, | 26,400 lbs. |
| 2d " | 1 " | round " | " | 34 " | " " " | 13-16 " | 16,800 " |
| 3d " | 1 " | square " | " | 18 " | " " " | 15-16 " | 14,600 " |
| 4th " | 1 " | round " | " | 22 " | " " " | 13-16 " | 13,200 " |
| 5th " | 1 " | round " | " | 34 " | " Norway" | 13-16 " | 18,720 " |
| 6th " | 1 " | square " | " | 30 " | " " " | 15-16 " | 19,200 " |
| 7th " | 1 " | square " | " | 18 " | " " " | 15-16 " | 15,600 " |
| 8th " | 1 " | round " | " | 22 " | " " " | 13-16 " | 14,400 " |

NOTE.—In test No. 6 Drift-bolts were not driven properly, holes not being in line, and a piece of timber split out in driving.

pears that the four square drift bolts, 1x1 inch, driven a total distance of 96 inches into the pine, required a force of 75,800 lbs. to extract them; while the four round bolts, 1 inch in diameter, driven in 112 inches required 63,120 lbs. The former is an average of 790 lbs. and the latter of 563 lbs. per lineal inch, or 71 per cent. of the former. The weight per lineal foot of iron one inch square is given by Jones & Laughlins at 3.368 pounds, and of round iron, one inch diameter, 2.645 pounds, or 78½ per cent. of the former. It would, therefore, seem from these results, that while in using round iron of the same diameter as the side of the square iron we save 21½ per cent. of the *weight of the iron*, we LOSE 29 per cent. of the adhesive strength. In other words, the same weight of *square* as of *round* iron requires 7½ per cent. more force for its extraction from pine.

In making my tests the greatest care and accuracy was used, and they can be relied upon as far as the samples experimented with by me were fair averages of their kind.

In consequence of these experiments I have adopted spikes ¼ of an inch square to fasten the knees to the cross-ties. Four of these spikes contain as much metal as one spike a half-inch square, but they hold, according to the foregoing experiments, 3,628 pounds, or more than double as much as one spike a half-inch square. Using spikes of small cross-section to fasten the knee to the cross-tie, it is evident that by increasing the number in the soft wood I can get as great holding power as may be necessary. As a matter of fact I have no difficulty in holding my tracks to gauge with cedar cross-ties.

### THE STRINGER.

The preceding remarks, concerning cross-tree timber, apply with equal force to the stringer, when it is of wood. Norway I use pine and think ten years is probably its average life. The quality of the soil, whether porous or compact; gravel, sand or clay, has more to do with the life of the stringer than that of the cross-tie, for, being nearer the surface it is reached more easily and affected by the alternate wetness or dryness. Few, if any, pavements remain water-tight, and more or less water penetrates to the foundation. Sprinkling the tracks with water, as practiced in most cities, so that the stringers are continually wet, prolongs their life. The selection of the timber itself has much to do with its service. For instance, my stringers are 5x7 inches. Very few sticks are entirely free from sapwood. The sapwood is the first to rot, and the top of the stringer, immediately under the rail, being most exposed, rots first. My stringers are dressed to pattern, planed on three sides. By selecting the *heart* of each stick to carry the head of the rail, where the car-wheel travels, I get increased service from the wood.

The top of the stringer should not be planed at right angles with its side, but should be inclined towards the center of the horse-path, so that the wheel will bear equally across the entire head; if anything a little more upon the *outside*. The car-wheel is cast with a cone shape; it is larger at the gauge-line than it is at the outside of the rail. This is supposed to lessen the resistance in passing around curves. My car-wheels are coned 1/8 inch in two inches My rail is five inches wide (step rail) and I incline the top of the stringer 3/8 of an inch in its width of five inches. The width of the wooden stringer is fixed by the width of the rail used, for they should be the same. The depth of the stringer should be such as to bring the top of the cross-tie beneath the pavement used. Seven or eight inches in depth suffices for this purpose, and the timber is strong enough to transmit the load upon it to the cross-ties. Mr. Wm. Wharton Jr. recommends that the cross-ties should be spaced five feet between centers. Some are laid three feet, four feet, five feet, six feet, and seven feet, between centers. I prefer four feet for a metropolitan line.

### MAINTAINING GAUGE.

Various methods are in use for holding the track to gauge. I prefer angle-irons, and place four upon each cross-tie. The two *inside* of the stringer in my practice, are fastened to the cross-tie by two boat spikes, each $\frac{5}{16}$ of an inch square and five inches long, with one spike driven into the side of the stringer, three inches long, $\frac{5}{16}$ square. The angle-iron upon the *outside* of the stringer I make the full height of the stringer and fasten it with three spikes, $\frac{5}{16}$ of an inch square and five inches long, to the cross-tie, and one spike into the stringer. I use old rail spikes for the latter purpose, ½ inch square. The spikes should be first driven into the stringer and then those into the ties. It is not necessary to enlarge upon the importance of having the knee fit snugly against the stringer. With a side-bearing rail, such as is used in Chicago, the weight of the car and its load is carried upon the outside 1⅞ inch of the stringer, and the tendency is to tip over. This is met and resisted by the aforesaid knees. The car wheels, unless the track be tight gauge, have little if any tendency to cause spreading or widening of the gauge. Not so with heavily loaded wagons in attempting to turn out of the track. The force exerted by the front wheels of such a load, drawn by four or more horses, is considerable. One-half the weight of the vehicle and its load must be raised over the head of the rail, one inch with us. The horses act with a leverage equal to the distance from the end of the tongue to the center of the front wheels; and this is the great force tending to spread our tracks. It is applied at the inside corner of the head of the rail, and the tendency is to turn the stringer over sideways. If the outside knees be firmly spiked and held to their position the lower inside corner of the stringer will come in, the top of the outside knee acting as a fulcrum. To prevent this motion a small knee is used on the inside of the stringer, and this force acting at the bottom of the said stringer, it is only necessary to have these knees high enough to get a small spike into the stringer without splitting off its corner. The use of cast-iron knees began before the existence of street railways, when steam railroads were built with strap iron for a wearing surface to protect the timber structure of which the railroad was composed. Upon the Utica and Syracuse R. R., previous to 1843, these knees weighed 1½ lb. and at the stringer joint 1$\frac{9}{10}$ lb. It is quite common upon street railways to make a knee with a wide top, for use at stringer joints so that a spike can be driven into the stringers at each side of the joint. The vibration of the pavement or track will cause the stringers to work up unless they are securely held down.

Upon some roads, rods of round iron ⅝ inch in diameter, are used instead of knees, to hold the track to gauge. A slot is sawed into the stringer at the top, seven feet center to center, to let in this round rod, which has upset ends with wrought-iron washers, say four inches square, upon it. These washers come upon the outside of each stringer, but are not adjustable for length. If the stringer be *just* the width intended, the washers bear, but if the stringer prove a little too wide, its side has to be dressed, and I have never seen any pains taken to cut off *just* enough. The men always cut out more than necessary, so to be sure to have enough, and then insert a chip to fill the void. This chip soon drops out, or at best rots, and the track spreads. The same result is reached if the stringer be narrow in the first place. Then these rods are more or less in the way of paving, and if they get bent, narrowed gauge results.

A bar of iron 1⅜ inches deep, by ⅜ inch wide has been used in Boston. It is twisted half way round at each end and let into the top of the stringer ⅜ of an inch, flush with the same. It has a square hole near each end. The stringers having been put to gauge, spikes are driven into them through the aforesaid holes; but I am informed that the vibration of the rail over these spikes loosens them.

Upon, light, country street railways, boat spikes are driven through the stringers into the ties beneath before the rails are put on. This construction makes it difficult to remove a tie for repairs, etc., for the boat spike can not be gotten out without first removing the rail which covers its head.

Tree nails of hard wood have also been used, and also blocks of wood to take the place of the iron knees.

## JOINT CHAIRS.

Joint chairs are made of various shapes and materials. Upon light roads, simple plates of wrought iron are used, placed on top of the stringer and allowed to settle into it. Other roads use wrought-iron or steel chairs, eighteen inches long and rolled, with sides projecting above and below. The former to hold the rails in line with each other, and the latter to hold them in line with the stringer beneath. Some rails have a hollow head. In that case, these joint chairs are made of cast iron. No lip upon the side is necessary, but it will be found advantageous to have the point chilled where the rails meet. Two-thirds of the length of the chair, in a track where the cars always pass in the same direction, should be placed under the end of the rail against the traffic, as experience demonstrates that that end receives a blow from the car wheel, and the rail cuts into the chair more rapidly than the rail upon which the wheel bears, and consequently needs more iron support.

## JOINT FASTENINGS.

I have given much study during some years to this question. The ordinary practice of our street railways with flat rails is practically the same that was introduced upon steam railways, with the use of strap rails laid on wooden stringers. Stevenson, in his "Civil Engineering of North America" in 1838, speaks of the practice then in vogue of putting plates under the strap rail joints, through openings in which spikes were driven. The specifications for track-laying on the Utica & Syracuse Railroad contained the following: "At each joint of the iron plate (rail) end plates shall be neatly fitted into the oak ribbons (stringers), so as to bring their upper surfaces in the same horizontal plane. The end plates shall be six inches long, two and a half inches broad (same as the rail), and a quarter of an inch thick." This was prior to 1843.

When street railways were inaugurated by the construction of the New York and Harlem in the city of New York, 1832, operated by horse power and laid in the street, it at once became evident that to protect the general public in the use of the street, the rails should be low and offer the least possible obstruction to the passage of vehicles. As other street railways were built, the shape of the rail was fixed by law. The rails have, in the majority of instances, been designed to serve merely as a protection to the timber structure. They vary in size and shape. Those most commonly used will be illustrated later. The various forms of joint chair have been above described.

The common practice in this country has been merely to spike the joints, through suitable openings in the chairs, to the stringer beneath. If carefully laid, this method affords a reasonably smooth joint for a time; but the weight of the loaded car presses down the end of the rail upon which it rests, and, no weight being upon the rail next in advance, it projects a little. The car wheel strikes this projecting end, deflects it and wears a trifle from the top of the chair and the bottom of the rail. This action taking place upon the passage of every car wheel (and upon some of the great lines *two hundred and forty* wheels pass in sixty minutes, four per minute), do you wonder that "bad joints" soon result? I have had joint chairs worn down on one end *one-quarter of an inch* in four years.

The spikes become loose almost from the start, and rapid depreciation follows. To avoid discomfort to the passengers, rapid destruction of rails, wear and tear on rolling stock and horse flesh, different remedies have been proposed. Abroad, bolts have been used, passing entirely through the rail, joint-chair and stringer, with a broad washer and nut on the bottom. The rails have been extended down at the sides and spikes driven through. Staples have also been used, one leg passing through an opening in the side of the rail and the other into the timber. While these fastenings are improvements upon the spike driven vertically, unless the stringers shall have been thoroughly seasoned they become somewhat loosened by its shrinkage. Condit, in his work on painting, quotes the measurements of Karmarch in Germany on percentage of timber shrinkage in seasoning: "In the direction of yearly rings pine shrinks from 5½ to 12.7 per cent.; white pine 4.1 to 8.13 per cent." If no other objection existed this would suffice, for most track timber is not thoroughly seasoned, and the shrinkage allows a little play at the joint, to be soon increased by wear.

Upon the flat tram rail, the water from rain, sprinkling, etc., follows along the tram, which serves as a gutter, being lower than the adjoining paving, sinking partially through spike holes in the rail, but chiefly at the joint. The recess cut into the stringer for joint chairs, beneath the rails, serves to retain this moisture, and *this* is the first portion of the stringer to become soft and rotten. The load upon each wheel of a city street-car, upon "rush trips," sometimes exceeds *three tons!* This great weight forces the chair into the stringer. If an ordinary spike fastening has been used it does not follow, and the rail end is loose and vibrates under each passing wheel. This is also, in a measure, true if a bolt has been used, passing through the stringer with a nut beneath. The carpenter who cuts into the stringer may have adzed true and level and the chair be "in wind" if of cast iron, or have slight projections upon its under surface, so that it does not take a firm bearing upon the wood until the weight of the loaded car wheel comes upon it. In such event the joint will soon have play, and rapid wear results.

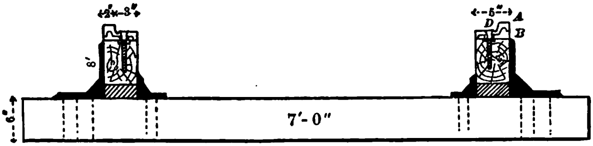


FIG. 1.

It has been proposed to fasten the rail ends to the joint-chair beneath by short bolts, but this fastening, leaving the joint unattached to the timber, allows the whole joint to vibrate under passing loads and wear into the wood.

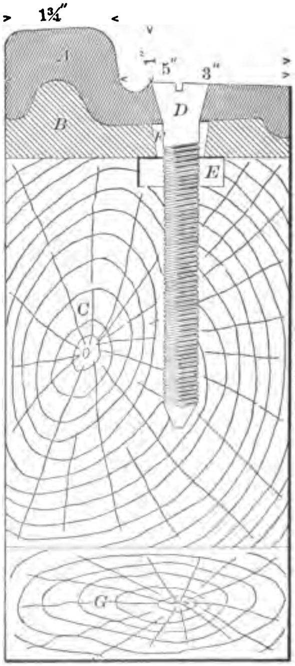


FIG. 2.

I patented a joint fastening, as the result of my investigation, as follows: Chairs may be of steel, wrought or cast iron, corresponding in width and shape to the rail. Under the chair two or more nuts are let into the top of the stringer, beneath holes in the chair and rails. The chair is then put in place, on the stringer, over those nuts through which holes have been bored in the stringer of less diameter than the hole in the nut. Suitable openings are provided in the chairs to allow contraction and expansion of the rails. The rails are then placed upon the chairs and a bolt screwed through the nut into the stringer beneath. The nuts fasten the rail ends to the chair, and they are thus held level with each other. The bolt below the nut is screwed into the timber and fastens the complete joint to the stringer.

This construction renders the joint fastening independent of all shrinkage of the timber. Should the chair settle into the stringer from any of the afore-mentioned causes, the nuts beneath carry *both* rail ends with them and no jar results.

I have used several thousands of these fastenings and the tracks are quite smooth. The difficulty with them is that the nuts rust fast to the bolts, and the latter will have to be cut to loosen the rail when the time comes to make repairs. Having sold this patent, I have no pecuniary interest in its use.

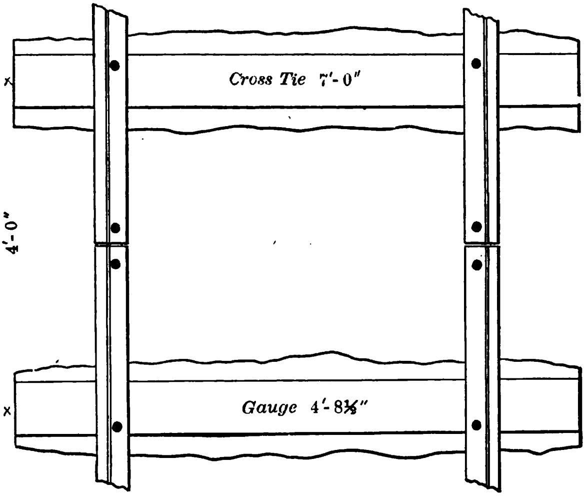


FIG. 3.

In the accompanying drawings, figs. 1 and 2 show my track construction in cross sections; fig. 3, a ground plan; fig. 4, top view of joint-chair. The letters all refer to the same parts in each drawing. A is the Chicago rail. Its extreme width is 5 inches. Head 1¾ inches at top, 2 inches at level of the tram, and the latter is 3 inches wide. Head is 1 inch above tram. It weighs 45 lbs. per lin. yard. B is the Chicago joint-chair of cast iron, 18 inches long, 5 inches wide, and weighing 15½ lbs. C, the stringer; D, the joint screw; E, the nut fastening the rails to the chair; F, opening through the chair for the fastening; G, an additional timber put under the stringer when the rail joint does not come over a cross-tie, as described under the head of "stringers." In fig. 4 the lines at H and I show where the rails meet on the chair. The two slots are provided so that right and left chairs may not be required, for, as before stated, two-thirds the length of each chair is placed under the rail against the traffic where cars pass only in one direction. The knees are shown, high outside, low inside of the stringer. The former weigh 7¾ lbs. The latter 2⅔ lbs. The tee rail and all forms of girder rail allowing fish plates, afford better joints, a fact referred to in a future page.

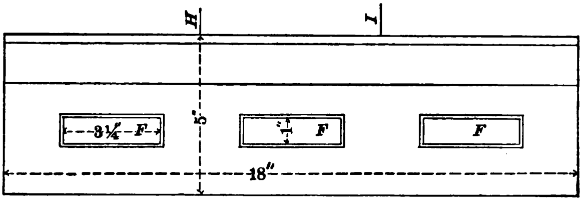


FIG. 4.

## RAILS.

The first point to be considered is whether steel or iron should be used.

In the past this has been an important matter, and has never received the consideration its importance merited. My thoughts were first turned to the question when asked by Mr. Clemenshaw, of Troy, at a convention of the American Street Railway Association. "You would recommend the use of steel rails, wouldn't you?" I replied in the affirmative, and felt safe in stating that one steel rail would outwear *six* iron rails. I spoke from my experience upon steam railroads; but this question caused me to ponder upon that subject.

The requirements of a rail upon a street railway and upon a steam railroad are quite different, and the experience of the latter is of little benefit to the former. Upon the street railroad, unless the girder rail be used, the rail serves merely as a wearing surface to protect the continuous timber structure. Steam railroads, as ordinarily constructed, use the rails as girders to carry the weights superimposed from bearing to bearing, *i. e.*, from cross-tie to cross-tie. They must be sufficiently strong to carry superimposed loads when their heads are worn out. Thus far the requirements of the two systems are entirely at variance. Now for the wearing effect of the traffic. In what does it consist? Dr. Dudley, the accomplished chemist of the Pennsylvania Railroad, has advanced a theory which has been much discussed. Allow me to quote Dr. Dudley, who, upon "The Wearing Power of Steel Rails," said: "The forces that act between the top of the head of the rail and the wheels in rolling friction may, it seems to me, be regarded as two in number. There is first a force, acting directly downward, due to the weight of the locomotive and cars. This force may be regarded as a vertical force, acting perpendicularly to head of the rail, and is in action both when the train is standing still and when it is in motion. Secondly, there is a force acting parallel to the head of the rail, due to the traction or impelling power of the locomotives. In the case of the driving wheels, this force may be supposed to act in the direction opposite to that of the motion of the train. * * * In the case of the drivers, the amount of this force, acting parallel to the head of the rail, is sufficient to overcome the total train resistance; in other words, to cause the train to move. In the case of the other wheels of the train acting individually, this force acting parallel to the head of the rail is small, being only that necessary to overcome the journal friction. The force parallel to the head of the rail acts only when the train is in motion. * * * Returning for a moment to the conception previously mentioned, that the top of the head of the rail and the surface of the wheel are a rack and pinion with infinitesimal teeth, but without regularity in the teeth, let us see what kind of a strain would be produced in these minute teeth by a force acting diagonally to the line of the head of the rail. I hardly see how we can avoid the conclusion that this strain would be a bending strain. * * * If we are right in regard to the nature of the surfaces involved in wear, and the strains produced, wear is simply the breaking or pulling off of the infinitesimal teeth by the strains to which they are subjected. And here we see why it is that the softer rails give the better wear, for the harder the steel the more brittle it is; and the more brittle the steel the more readily will these infinitesimal teeth be broken off by the strains applied."

Dr. Dudley wrote me, December 21, 1885, in relation to the above paper:

"We have not studied the subject very closely and continuously since our papers were published in the proceedings of the mining engineers. The observations, however, that have been made since that time strengthen us in the view that the conclusions there are practically correct, and it is our firm belief that ultimately steel rails will be made more in accordance with the formulas then brought forth than at present."

A Pennsylvania engine for passenger service, Class K., weighed, in working order, 96,700 lbs., of which 32,900 lbs. were on the forward drivers. Mr. Chanute made some experiments upon the Erie Railroad. He found that a driving wheel five feet in diameter bore upon the rail head a space not greater than the thickness of a knife blade, about one-quarter of a square inch. Ten thousand pounds being the weight upon this driving wheel, the static pressure equaled 40,000 lbs. per square inch. *This* is the great force coming upon steam railroad rails! It is to stand up under the locomotive that the rails must be designed. It is the locomotive that does the most damage and causes the greatest wear upon its rails.

*Now, this force does not exist upon* horse or cable railroads. All the rail has to do in their cases is to resist the wear coming from journal friction, and the latter, together with flange friction, is estimated by M. N. Forney at 6.1 lbs. per ton at a speed of 5 miles per hour. Steam railroads, therefore, need a stronger material for rails than iron, and this is met in steel.

I have used the words iron and steel. What do they mean? It is the same as if I spoke of wood and stone. There are many varieties of each, possessing very different qualities as to hardness, strength, etc.

Iron, when chemically pure, is one of the elements. Its atomic weight is 56, but it is doubtful if it occurs native. Its *ores* are very numerous, and they vary greatly in quality. In speaking of iron, I mean the ordinary commercial article known by that name, and of average quality and workmanship. A certain amount of carbon changes the appearance and quality of the product. Thurston states: "Steel is variously defined by acknowledged authorities, and the metals known in the market and to the trade as steel, can not be completely and satisfactorily classed under any definitions yet proposed. The term includes, as formerly accepted, all impure irons which, in consequence of the presence of other elements, have the property of hardening by sudden cooling from a high temperature, and of taking a definite 'temper' or degree of hardness by a definite modification of temperature, and which may also be forged. It has been recently proposed to define steel as a compound, consisting principally of iron, which has been rendered homogeneous by fusion. Still another definition is 'iron recarbonized.'"

Alex. L. Holley, the father of the steel works of this country, said: "Steel is an alloy of iron which is *cast while in a fluid state* into a malleable ingot. Any radical nomenclature founded on chemical differences leads to endless mistake and confusion. If steel is defined as an alloy of iron containing carbon enough to harden it when it is heated and plunged into water, then puddled iron, although laminated and heterogeneous in structure, may be steel, and the finest product of the crucible, although crystalline and homogeneous in structure, may *not* be steel. The fundamental and essential difference between steel and all other compounds of iron is a structural difference, and it is always easily determined, while steel and wrought iron can not always be distinguished by chemical analysis. The same proportions of carbon, manganese, silicon and other elements may exist in and similarly affect any malleable alloy of iron. Steel is, therefore, an alloy of iron which is cast into a malleable mass."

My friend, Col. G. Howard-Ellers, defines steel as "an alloy of iron, carbon and nitrogen, containing a less proportion of carbon in a graphitic or combined condition than is found in carbide of iron, when in the condition of *pig metal.*"

An iron rail is, as it were, made fibrous by the process of rolling. A steel rail is homogeneous, and not fibrous. The iron rails upon steam railroads fail chiefly by lamination. "Lamination," wrote Louis Nickerson, "is the result of some natural and determined law, and that law is this: 'That all material, when subjected to pressure, laminates in planes perpendicular to that pressure.'"

This law was announced by Prof. Tyndall after his experiments upon lamination. Ure's Dictionary of Manufactures and Mines does not agree therewith. It states: "Careful examination convinces the writer that whenever lamination of the rail becomes evident, it can be traced to the imperfect welding together of the bars of which the rail is formed." And again: "An objection has been urged against malleable iron rails on the ground that the weight on the wheels rolling upon them expanded their upper surface and caused it to separate in thin laminæ. In many of our large stations rails may be frequently seen in this state, layer after layer breaking off; but this may be regarded rather as an example of defective manufacture than anything else."

Holley & Colburn wrote: "Rails rarely wear out. They laminate or crush in the majority of instances."

Ashbel Welch, chairman of the committee, reported to the American Society of Civil Engineers, May, 1875, upon the subject of rails, from which I extract: "The chairman of the committee was so much surprised at so little difference in the loss of metal in iron and steel rails, that since the former report was presented he made further examinations. * * * The average loss of metal was, in the steel, 0.29; in the iron, 0.325 lbs. per yard. This shows if iron were perfectly welded, and as hard in the middle as at the top, and never loaded so as to crush or condense the metal (say not over 25.000 lbs. per square inch), it would wear nearly as long as steel."

It would appear, from the above quotations, that the cause of failure of iron rails upon steam railroads, supposing the rails to have been properly manufactured, has been the excessive weights imposed upon them. This is absent from horse railroad tracks, and I am not surprised at the following results as stated by D. K. Clark in his work on Tramways: "Preparatory to deciding upon material—iron or steel—for the rails (Glasgow Tramway) of the new system of way designed for hauling by mechanical power, the results of the comparative wear and tear of iron rails and steel rails, under like circumstances, were investigated by the engineers, Messrs. Johnstone and Rankin. Two rails of the earliest sections, one of iron and one of steel, laid in Paisley Road within a few yards of each other; and two rails, one of iron and one of steel, laid in Argyle street, were weighed when they were laid and when they were taken up. The loss in weight of the Paisley Road rails in 7 years was, iron, 44 lbs: steel, 43½ lbs.; Argyle street, 6 years, iron, 39 lbs.; steel, 33 lbs"

Steel should be mild. John W. Cloud, of the Pennsylvania Railroad, in the discussion of the paper by Dr. Dudley, already referred to, stated: "We should study the physical properties of steel in relation to its wearing power, and ask the makers to give us the requisite wearing properties, and leave the chemistry to them. The evidence that softer steel does give greater wear in rails is conclusive. At Altoona careful examinations have lately been made of locomotive tires, and from one to two inches difference has been found in the diameters of the tires of wheels upon the same axle. Invariably, when these two tires are put into the lathe, it is found that the tire most worn is the hardest."

Iron glides imperceptibly into steel. It is difficult to fix the boundaries between them.

Upon a portion of the Great Eastern Road, in Great Britain, wrought iron rails wore thirty-three years. Upon the Montreal street railway wrought iron rails have worn twenty-three years.

The coning given to car wheels allows only a very small surface to come in contact with the rail head. M. N. Forney, in his paper on "Rail Sections and Flange Wear," states that the load thus brought upon the rail head is from 40,000 to 60,000 pounds per square inch. This is on steam railroads. The *Railroad Gazette*, November 28, 1884, states "that a cast-iron car wheel, of one of the patterns now largely in use, when running with its flange against the side of a certain rail largely used, has a cross bearing of no more than $\frac{3}{16}$ of an inch in extent. The area of the bearing surface under a 33-inch wheel in such case is $\frac{1}{8}$ of a square inch. With the surfaces between wheels and rails no greater than they now, quite commonly, are, the weight borne by the opposing surfaces is, in the case of a fully loaded eight-wheeled twenty-ton car, about 60,000 lbs. per square inch."

A prominent car wheel manufacturer tells me that he gives a slope or cone of $\frac{1}{8}$ inch in four inches upon his steam railroad wheels, and $\frac{1}{16}$ inch in two inches for the street car wheels.

As explained under the head of stringers, my stringer top is inclined to equal this coning, and my wheels bear entirely across the rail head. The average load per car wheel upon the North Chicago Railroad is 1,875 lbs., and probably 6,500 lbs. is never exceeded. The average weight therefore, imposed upon my rail head is 2,600 lbs.; the maximum 17,333 lbs. per square inch. The latter is about two-thirds the weight considered necessary by Mr. Welch to crush the rail.

The speed upon the steam railroad is another important factor in the wear of its rails. The mud that covers the head of the street rail in Chicago nine-tenths of the time, affords a grit of greater or less sharpness, and our rails and wheels are literally ground out. The life of our car wheel is about half the number of miles that the wheel of the same manufacturer makes upon steam roads, *i. e.*, 30,000 miles. The average loss of metal in our entire steel rail equalled 5 per cent. per annum; but more in the head than in the tram.

It is impossible to adduce statistics of American street railways as to the relative service in tons passing over a certain rail. No company knows or can know.

I could ascertain the number of car *wheels* that have passed over a certain rail in my track, but *not* the weight upon that car wheel, for I have no means of ascertaining the point along that line at which the different passengers entered or left the car, nor the traffic of public vehicles passing along the rail.

I believe that in adopting steel the street railways simply followed steam railroad practice, without giving the question any consideration; but you have seen that when wooden stringers have been used, the requirements of the rail in the two systems are quite at variance. Aside from all questions of wear, human life is not endangered by a broken street rail, passed over with a speed of six miles per hour, as by a steam railroad rail at from four to eight times that speed.

I have yet to hear of an American Street Railway Company having prepared specifications for its rails.

Whether of iron or steel, they usually simply invite "bids" from manufacturers, paying the least obtainable price and *trusting to the maker to furnish a good rail.* Manufacturers are human. They are not going to do work without a profit. It speaks volumes in their praise that poorer rails have not been furnished. No inspection! No specifications! Simply a reliance upon their honesty.

When the strain upon them has been too great they have yielded. Poor material and inferior workmanship have given wretchedly inferior rails. If of iron, the manufacturer, looking for some loophole of escape, attributes the failure to anything but himself, and says: "Iron will not stand." "It can not endure the heavy traffic," etc.

I have gone at length into this question, because it seems not to have been considered by street railway officials. It is a dead issue to-day, because few iron rails are made, and increasing uses are being found for old steel.

I have used nothing but steel for some years, but in attempting to dispose of some that had worn out in less than five years, I found in this market I could obtain from 25 to 50 per cent. more for old iron scrap than for old steel scrap, with many times the demand for the old iron.

No one claims that iron will wear longer than steel, but it seems to me that, of average quality, the one will wear about as long as the other in street railroad tracks, and iron is cheaper so long as it commands the greater price as old scrap.

The first cost of iron and steel is the same at the present time. The requirements of a girder rail, no wooden stringer being used, are more nearly the same as upon steam railroads, and a mild steel is best.

Wm. Wharton, Jr., A. J. Moxham and others have no hesitation in declaring that from every point of view steel is preferable to iron for street rails.

### SHAPE OF THE RAIL.

Having determined the material for the rail, its shape next merits consideration.

Unfortunately, the Street Railway Company is not permitted to select such form as it desires; but this is usually regulated and fixed by law so far as the upper surface exposed in the street is concerned.

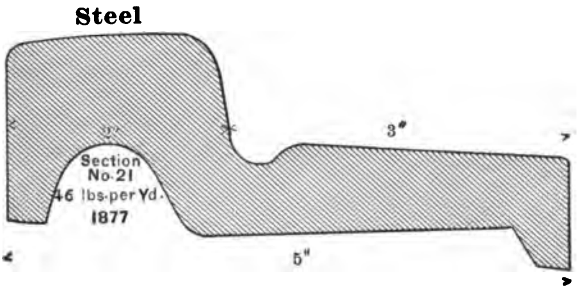


Fig. 5.

The following are quite common forms of rails:

Figure 5 shows the rail used in Chicago. The municipal ordinance states the rail head shall be two inches wide

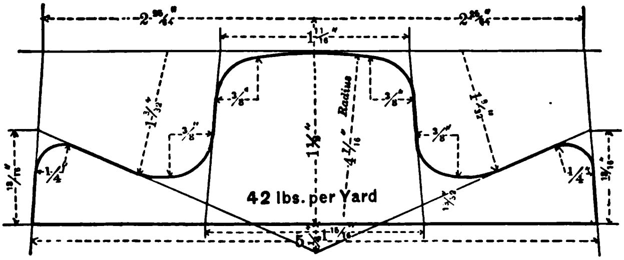


Fig. 6.

and the tram three inches wide, for use of the general public. The height of head above the tram is one inch, and the adjoining pavement next the head must be level therewith. This rail weighs 45 lbs. per yard.

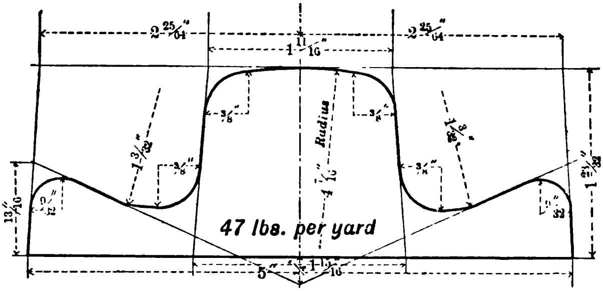


Fig. 7.

Figs. 6 and 7 show a center bearing rail used in South Boston, Louisville, New York City, Montgomery, Ala., Charleston, S. C., etc.

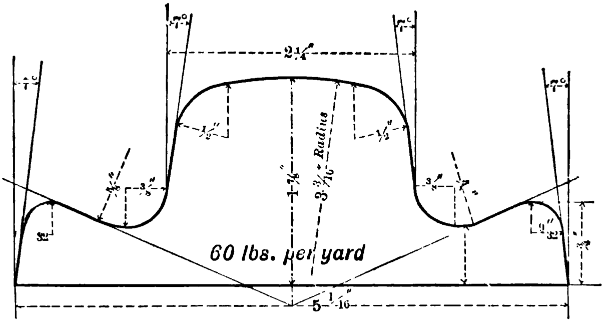


Fig. 8.

Figure 8. Center bearing rail, standard pattern, New York City and Brooklyn.

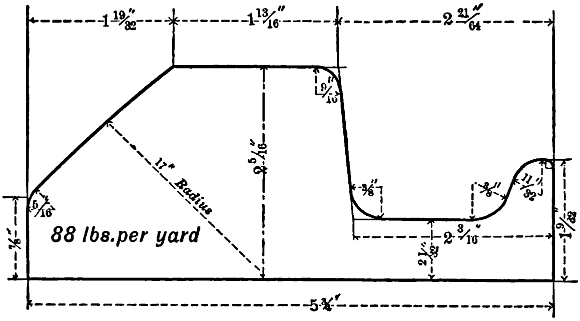


Fig. 9.

Figure 9. Slope back rail. Used on steam street railroads.

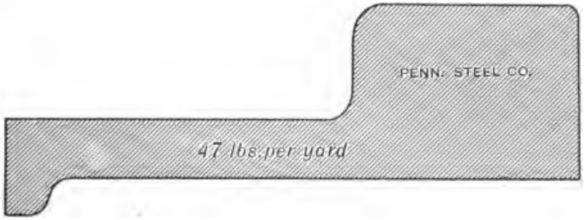


Fig. 10.

Figure 10. Standard Philadelphia rail. Used also in Baltimore, Providence, R. I., Jersey City, etc.

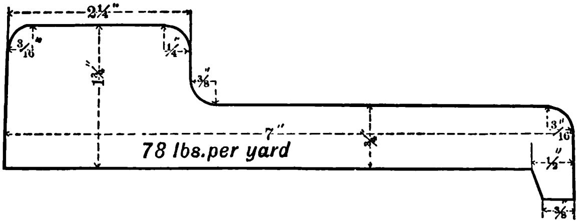


Fig. 11.

Figure 11. Used on some Philadelphia railroads.

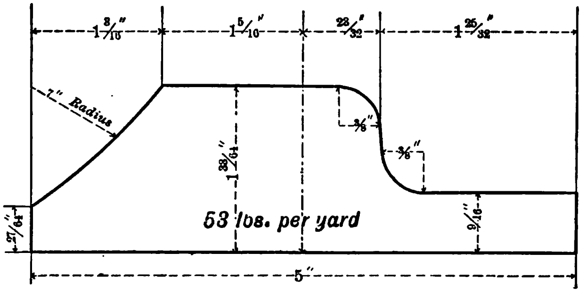


Fig. 12.

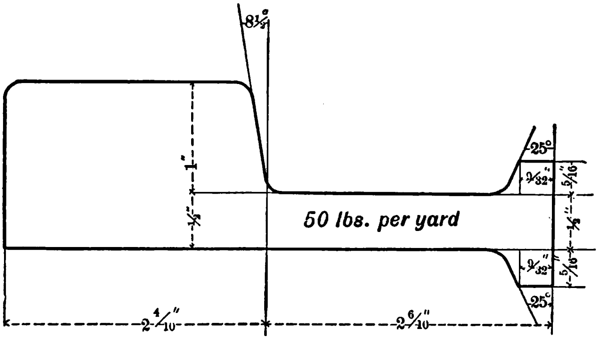


Fig 13.

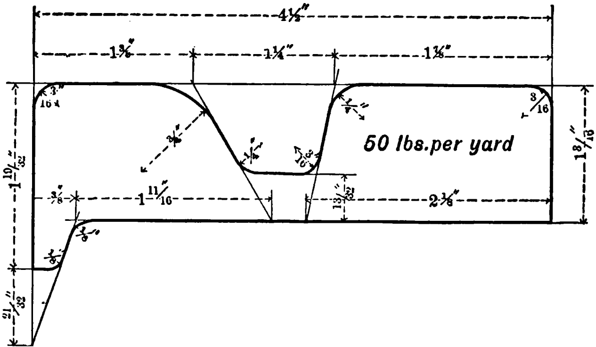


Fig. 14.

Figure 12. Slope back rail. Brooklyn City Railroad.
Figure 13. Standard pattern for Boston Street Railways.

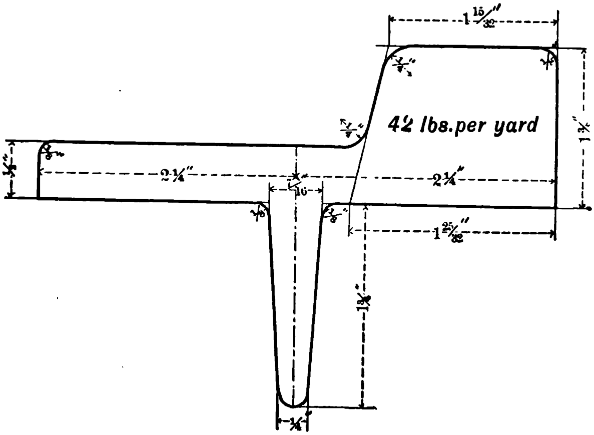


Fig. 15.

Figure 14. Used by the North Baltimore Railroad.
Figure 15. Used by Albany Street Railway Company.

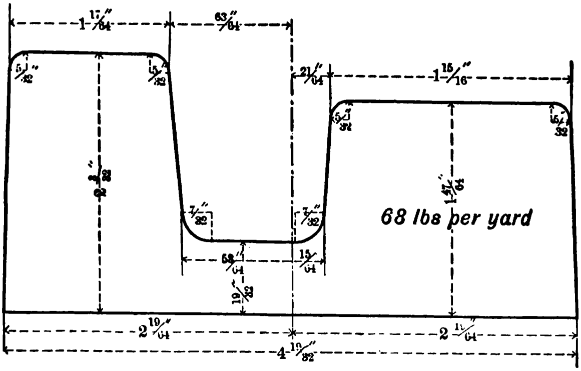


Fig. 16.

Figures 16 and 17. Standard grooved rails for curves. Used very extensively. I am indebted to the Pennsylvania

Steel Co. and Wm. Wharton, Jr. & Co., both of Philadelehai., Pa., for these drawings.

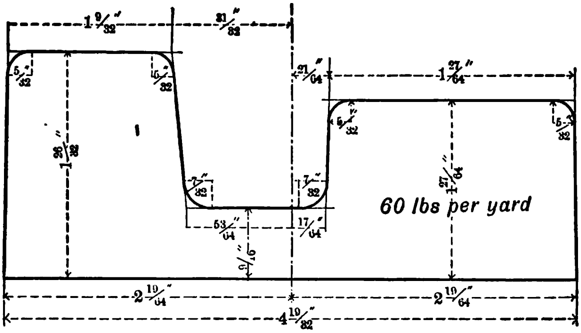


Fig. 17.

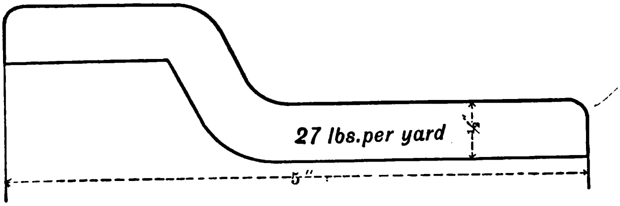
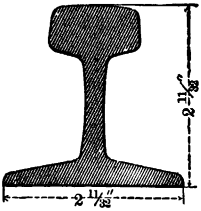


Fig. 18.

Figure 18. Used by Milwaukee railways and elsewhere.

TEE RAIL
*16 lbs. per yard.*



Fig, 19.

Figure 19. Tee rail, used on many roads in the smaller towns.

Figures 20, 21 and 22. A girder rail, made by the Johnson Steel Street Rail Co., Johnstown, Cambria Co., Pa., to whom I am indebted for the drawings. This girder rail is used so extensively, that I must omit to designate the various cities and towns.

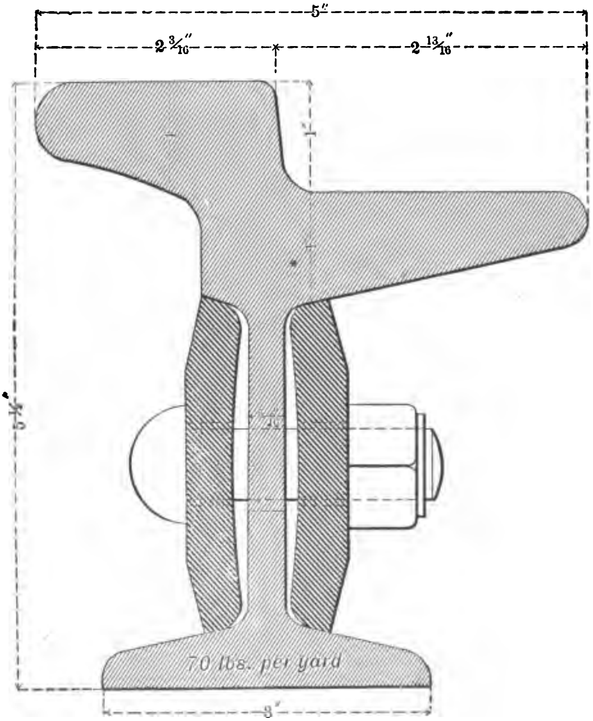


Fig. 20.

I feel no hesitation in affirming that every street railway in the country would select the center bearing type from among these rails, if they were permitted to choose. Its advantages are as follows:

1st. Lessened resistance to progress. From information in my possession, I think 25% less power is required to keep a car in motion upon the center bearing rail, than upon a side bearing rail. The latter rail head is level with the adjoining pavement on the outside, and is usually covered with mud, sand, dirt, snow or ice. The center bearing rail, having the head higher than either side, is comparatively clean.

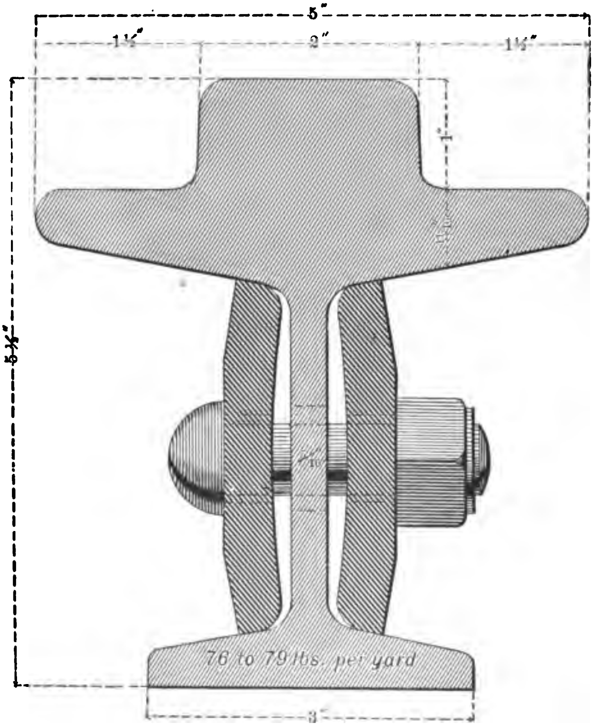


Fig. 21.

2nd. The weight of the car and its load is carried on the center of the stringer and does not tend to turn the latter over, as in the side bearing pattern. This I do not consider of much importance, for it is not the car wheel that spreads our tracks! They are spread by the heavily loaded teams, turning out, as explained upon a previous page.

3rd. It can be, and is, more securely fastened to the stringer beneath. In the step rail, the spike holes are all in one side, through the tram. Every wheel passing on the tram, goes over the spike head and it is jarred and loosened, while the center bearing rail is spiked on both sides of its head and only half the spikes are subjects to these blows.

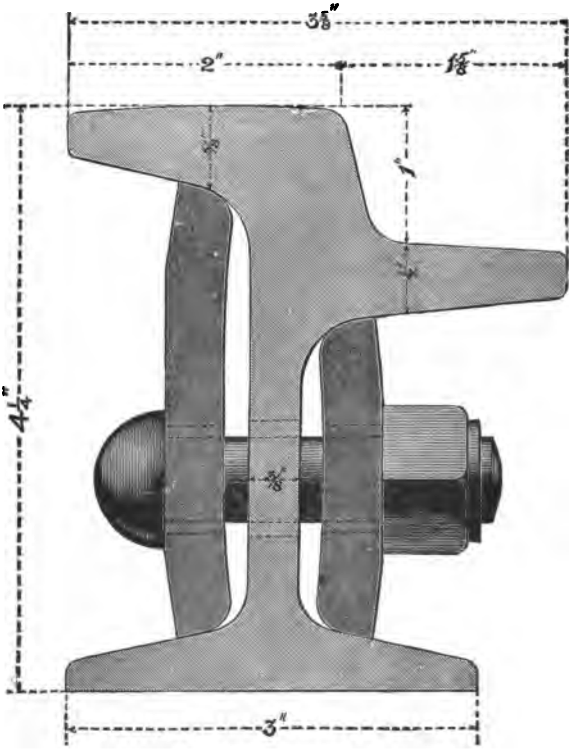


**Fig.** 22.

The disadvantage in the use of the center bearing rail is that it offers a poorer tram for the use of the general public, who seek the smooth way afforded by the street car rails, to an extent realized by few. I have upon a previous page, given you some statistics as to the relativetravel upon the tracks of the North Chicago Railway and upon the balance of the street, but have no statistics to prove to how great an extent heavily loaded teams leave side streets and travel along the rails. Now there can be no *cheaper pavement than steel or iron at present prices.* It is economy to maintain the adjoining pavement in such condition that the heavily loaded teams that *will* seek the car tracks, can get onto the rails. To the extent that the step rail affords a better wagon way than the center bearing rail, and saves the wear of the adjoining pavements, supposing they must be maintained by the Street Railway Company (which is the usual custom) is the step rail more economical, so far as track repair expenses to pavements are concerned; but there should be deducted an uncertain amount; the lessened teaming, that seeks the tracks when the center bearing rail affords a poorer tramway, and the decreased wear along the paving when the center bearing rail affords *two* narrow instead of one wide tramway for vehicles.

## FASTENINGS FOR RAILS.

The usual custom in this country is merely to drive spikes through the tram, if the side bearing rail be used, or through each side of the head, if the center bearing rail be used. No street railway man needs to be told how wretchedly these spikes do their duty. In the former case, every spike head, and in the latter, half the spike heads are subjected to a blow from the wheel of every passing vehicle. The rails having little vertical stiffening, especially the former, vibrate under the wheels of every passing car and other vehicle. Water penetrates into the enlarged holes around the spikes, and decay adds to the mischief, making a bad matter worse. This vibration enlarges the holes in the rails, until, in four years time, steel rails in my main track had hardly a hole through which my spike head would not pass. For this reason, it is my custom to spike through alternate holes, leaving one half, when new tracks are laid, for future use. The holes should be not more than twelve inches apart.

D. K. Clarke wrote: "A completely constructed tramway must, therefore, combine a perfect, unyielding, rolling surface, with a firm and durable pavement. The first condition—a perfect rolling surface—it was impossible to fulfill so long as the rails were fastened by vertical spikes or bolts passing through the groove in the rail." And again: "Moreover, the flat rail and the vertical spike or bolt fastening made a defective combination. It is scarcely necessary to say that, at best, the form of the flat rail combined the maxt imum of material with the minimum of strength and stiffness, whilst the vertical spike fastening, though it is simple, and appears at first sight to have been happily devised, is deficient in strength and durability, and contributes nearly nothing towards the union of the rail with the sleeper (stringer). The rail, especially at the joints, is liable to spring, and the spikes, with their shallow, countersunk heads and limited bearing surface, are liable to yield and to wear; the spikes, in consequence, are gradually loosened, and the heads are lifted and torn or broken off. The spike heads are further exposed to damage from the wheel flanges, which, like the rail, become worn, ground in the groove, and occasionally split the rail. (This applies to the groove rail used in England.) Wherever there is vertical movement, of course an entry for water is made, pumping action ensues, and rain water alternately sinks through the spike holes and by the sides of the rails, and rises to the surface laden with sand and other detritus. The rails and sleepers are gradually undermined, the sleepers (stringers) are deformed by blows, and the vertical instability is by so much increased."

And again: "But a method of fastening the rail to the sleeper (stringer) was wanted, which should be free from the defects of the vertical spike—a method the barbarity of which was only rivalled by its simplicity."

American street railways have long recognized these facts, but it is only within a short time that the "girder rail" has been in the market.

## THE GIRDER RAIL.

Among the advantages offered by this type of rail, I place:

First. The fact that it is fastened to the cross-ties at its bottom, below the action of all passing traffic.

Second. Its increased stiffness and consequent absence of vibration under superimposed loads.

Third. The absence of timber stringers.

Fourth. Better joints.

It needs no words of mine to satisfy you of the importance and value of the fact that the spikes are protected. All motion of the rail is prevented vertically, and in contracting or expanding under varying temperatures, it slides *through between the spike heads.* In the flat rails this motion cannot take place without moving the spikes more or less along each side from the centre to the rail end; and practically it is irresistible.

As to its increased stiffness. The ordinary step rail possesses so little vertical stiffness that the timber has to carry the entire load. The rail would deflect to such an extent that the timber would break. The elastic limit differs in the rail and the timber. The centre bearing rail is stiffer than the side bearing.

A. J. Moxham quotes the following: "Tests for transverse strength made at Cambria Iron Co.'s Works, Johnstown, Pa., June 7th, 1883.

Supports 17 inches apart, rails all steel.

1. Tram rail, weighing 45 lbs. per yard; depth of head 1½ inches; width do., 2 inches; depth of flange 9-16; width do., 3 inches. Total width 5 inches. Elastic limit 15,000 lbs. Ultimate strength 32,000 pounds.

2. Test of same rail on pine stringer 5 inches wide and 9 inches deep.

At 20,000 lbs. timber much compressed. Signs of yielding.

At 25,000 lbs. timber commenced to crack.

At 27,000 lbs. timber gave way, the two ends thereof were compressed ⅞ inch, having reduced the depth to 8½ inches.

3. Test of Johnson girder rail weighing 52 pounds per yard.

Elastic limit 80,000 lbs.

Ultimate strength not reached by machine. At 122,000 lbs. the permanent deflection was ¾ of an inch."

The quiescent breaking load of a horizontal beam, supported at both ends and loaded at the centre, is found by multiplying the square of its depth in inches by its breadth in inches, and this sum by a coefficient found by experiment, and dividing the product by the clear span in feet. This stringer being 9 inches deep and 5 inches wide, and of pine, whose coef. has been found to be 500 lbs., and clear span 1.42 feet, we have $\frac{9^2 \times 5 \times 500}{1.42} = 14{,}265$ lbs., which would have been its breaking load, had not the rail distributed the weight. As a rule this girder rail is five times stiffer than the step rail and stringer. The rule for stiffness follows a different law. The deflection within elastic limits of a rectangular beam is in proportion to the load multiplied by the cube of the span, divided by the breadth, multiplied by the cube of the depth.

The absence of timber stringers.—Upon most of the mileage of street railways of this country, the rails outlast the stringers! It is poor economy to lay old rails upon new timber!

"No man putteth a piece of new cloth onto an old garment."

Practically, therefore, the life of the timber should measure the life of the rail, but in this event more or less good metal is thrown away!

I thought that for all street railroads with LIGHT traffic the girder rail was unquestionably the best, but for lines with HEAVY traffic, where one stringer would last as long as two rails would wear, the wooden stringer was preferable. Further consideration has convinced me that the girder rail is better, so far as the track is concerned in all cases. Why did my steel rails wear out and have to be replaced within less than 5 years? Because of the wretched fastening and consequent vibration. I am of the opinion that the better fastening, greater stiffness and better joint of the girder rail, will prolong its life to a point beyond that of the wooden stringer! *Permanency* is what all street railways desire in their track construction. Besides the inconvenience to the public in track renewals, the loss to the company is great. $500 per diem does not cover the decrease in receipts upon many a line from traffic interruptions; and if rival lines exist, a portion of this sum is permanently lost to the company, for men are creatures of habit, and are apt to continue to use a line after becoming accustomed so to do. Half the cost of a street railway or more is in the pavement, and this must be more or less destroyed in renewing the tracks.

Under the head of "Joints," I have written upon those in use for the ordinary rail. The girder rail permits of a fish plate joint, infinitely superior to any that can be made for the flat step rail. If the fish plates are securely fastened, of suitable form and strength, the load upon the street rail is not great enough to get them out of order. They hold the rails in line horizontally and vertically, and the improved joint saves to the company horseflesh, wear and tear on cars; its popularity is increased with its passengers to the same extent, by an absence of a jolt or jar 176 times per mile if the rail joints came opposite, and the rails are 30 feet in length, or 352 joints when they do not come opposite.

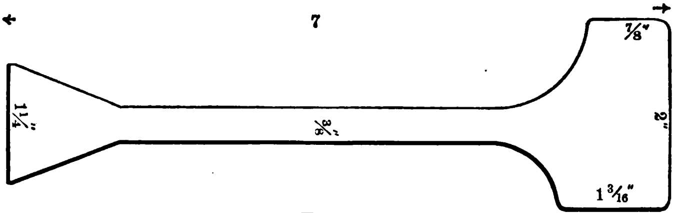


FIG. 23.

As remarked upon a previous page, no dependence should be placed upon the pavement to hold the track to gauge. On all metropolitan lines tie rods should be used not more than seven feet apart. I would recommend a rectangular bar rather than a round rod, as offering less obstruction to paving.

Seven or eight inches, at least, in depth should be furnished, from the top of the pavement to the cross tie. This is provided by the use of chairs, extending from the bottom of the rail to the cross tie, and the attachments between the rail and chair should be such that the rails can be removed when worn out, without having to go down to the cross tie.

### PROVIDENCE GIRDER RAIL.

Figure No. 23 shows a cross section of a rail weighing 54 lbs. per yard, patented by Lodowick Brayton, President of the Union Railroad Company of Providence, R. I.

Figure No. 24 is an isometrical view of a joint, and Fig. No. 25 an isometrical view showing construction in a street when cross-ties are used.

The chair under the rail as shown in Fig. 24, is two feet in length, and it is recommended to place them 7½ feet apart on centres. The cross rods ¼″ × 1,½″ deep, are put in each 5 feet. They have a nut inside and outside of each rail. At the rail joints two fish-plates are used 8″ × ½″ × 4½″ each, secured by bolts with nuts as shown in Fig. 24.

The method of construction is simple and rapid. The rails are laid in trenches, dug along the proposed line; tie-rods are then inserted, and chairs keyed to the rails. Small blocks of wood (say 2′ × 4″ × 6″) are put under the rails at proper intervals, and the track is lined and surfaced on them, as with cross-ties. An excavation is then made under each suspended chair to the required depth (6″ to 8″) and filled with a concrete composed by measure of 3 parts sand to 1 part cement, mixed with broken stone. A quick setting cement is used, so that two hours suffice for it to harden, when the blocks are knocked out and the weight carried upon the concrete. It is claimed that the process is simple and inexpensive, and the results very satisfactory; after severe cold, when the frost had penetrated four and five feet into the ground, numerous examinations were made but the concrete was found undisturbed.

As indicated in figure No. 25 wooden cross-ties can be used with suitable chairs, but the manager does not favor this plan, preferring to exclude *all* wood.

Seven miles of this track have been laid in Providence, and in 1886 it is expected that eight miles more will be put in.

As this rail has no tram, it is considered desirable, especially when laid to standard gauge, to put a course of granite on the inside of each rail, say 6" wide, and to put them on the same kind of cement foundation as the rails.

It is estimated that 125 barrels of cement suffice for one mile of track.

The balance of the paving is either granite or cobble according to the traffic in the street.

Clearance for the car-wheel flange is obtained by paving the horse path lower than the head of the rail.

It will be noticed that this rail has no tramway for ordinary vehicles. This construction is endorsed by the Mayor, City Engineer, Aldermen, etc., of Providence, and it is claimed that the rail is not so much of an obstruction in the street as a tram-rail. From a company's point of view, if the street traffic be very heavy, granite is more expense than steel or iron, as paving.

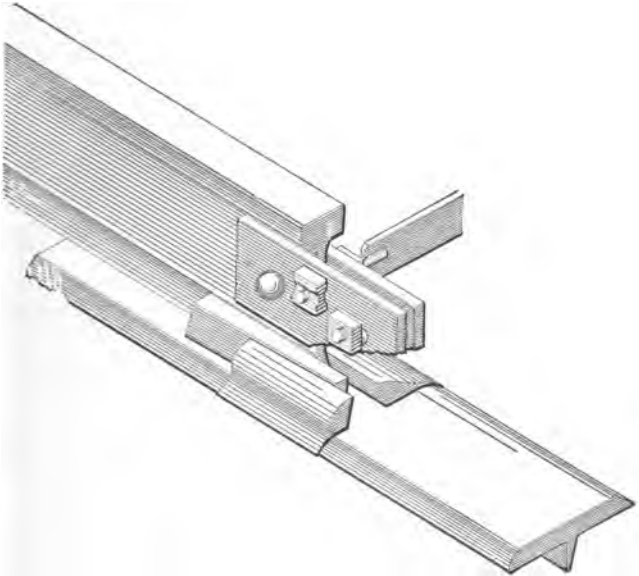


FIG. 24.

On my main line, granite blocks next to the rail were worn down ½ in. in two years, and had it not been for the tramway, the wear would have been greater; for the bulk of the travel is on the tram of the rail.

I am indebted to Mr. D. F. Longstreet, Vice President and General Manager of the Union R. R. Co., of Providence, R. I., for the drawings, etc., pertaining to this rail.

### GIBBONS METALLIC STREET RAILWAY TRACKS.

The accompanying Figure, No. 26, shows an isometrical view of this construction. Figure 1 represents a cast-iron box, the top of which equals in width the rail, the bottom is wider. There is a continuous slot along the top, to permit the entrance of a projecting bottom flange of the rail, the top surface of which is similar to an ordinary centre-bearing rail, Figure 2.

These boxes are laid in trenches. T shaped mortises in their sides permit the insertion of tie-rods, which pass through the lower projection of the rail, as shown at 4. They are then keyed, to hold the track to gauge.

The batter given to the side of these cast-iron supports interferes with any paving unless the latter is dressed to the same inclination, for it would touch at the bottom, leaving an opening at the top. A better construction would be to widen the bottom below the pavement. The projection upon the bottom of the rail, and in fact the general idea of this construction is quite similar to that designed by W. J. Cockburn-Muir, and patented in England in 1870, and adopted for all the tramways at Monte Video. It was also used at Buenos Ayres, Salto and Bahia, Vienna, Palermo. In his system these cast iron boxes are turned upside down, filled with gravel or coarse sand, and closed with a hand-board. Then returned into place, when the board is slipped out. They are laid upon the ground, or upon a prepared bed of concrete. (See D. K. Clark. "Tramways.")

It is an admirable construction, and Mr. Clark states: "After having been down in Buenos Ayres upwards of ten years, Mr. Cockburn-Muir's way has stood well, and has given great satisfaction."

Mr. Gibbon in answer to my questions wrote to me January, 7, 1886, from Albany, N. Y.: "I have laid about 1½ miles of track in this vicinity, since Dec. 6, at intervals (between frosts) and which is now open, and well patronized by the people.

Our system is very simple. When the trenches are dug, the track is rapidly and accurately laid, for you will observe

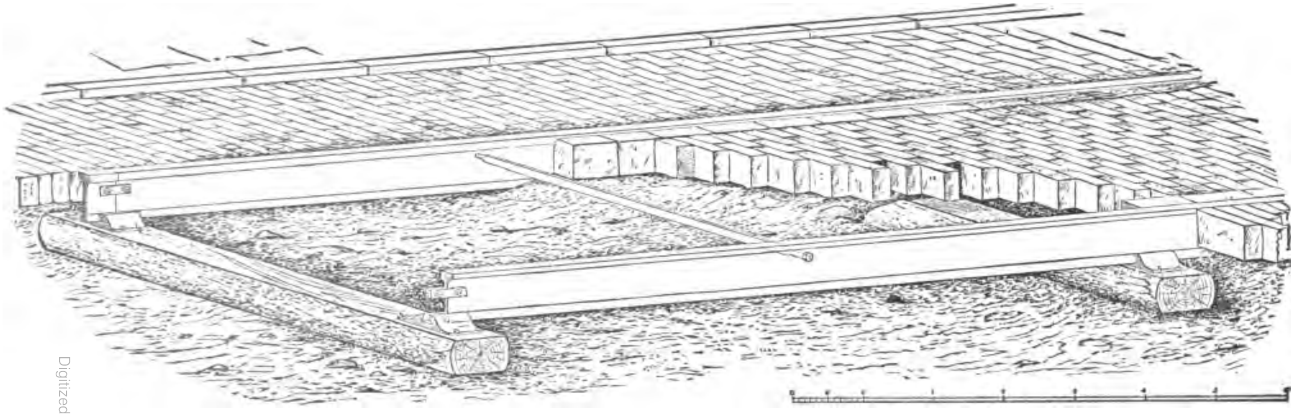


Fig. 25.

the web of the rail, compels the stringer to be in line; otherwise the web would not go into the girder. When in, the combination has enormous strength against lateral thrust.

The rail flange has an even and uniform bearing on the stringers, and the web of the rail is a very stiff girder for vertical stiffness.

The tie rod is notched, or shouldered, so that when the notch fits in the mortises, inside of box, not only ties them together, but is a true track gauge also.

I would not hesitate to say that in seasonable weather, with 24 men, and trenches dug I would lay upwards of ¼ mile of track, levelled up and ready for pavers.

The men would be classed as follows:

4 men placing stringers, fixing tie rods, 2 in each trench.

4 men filling stringers with sand and tamping.

6 men placing rails in stringers.

2 men driving wedge keys through mortices in rail and stringers.

8 men levelling and surfacing ready for pavers.

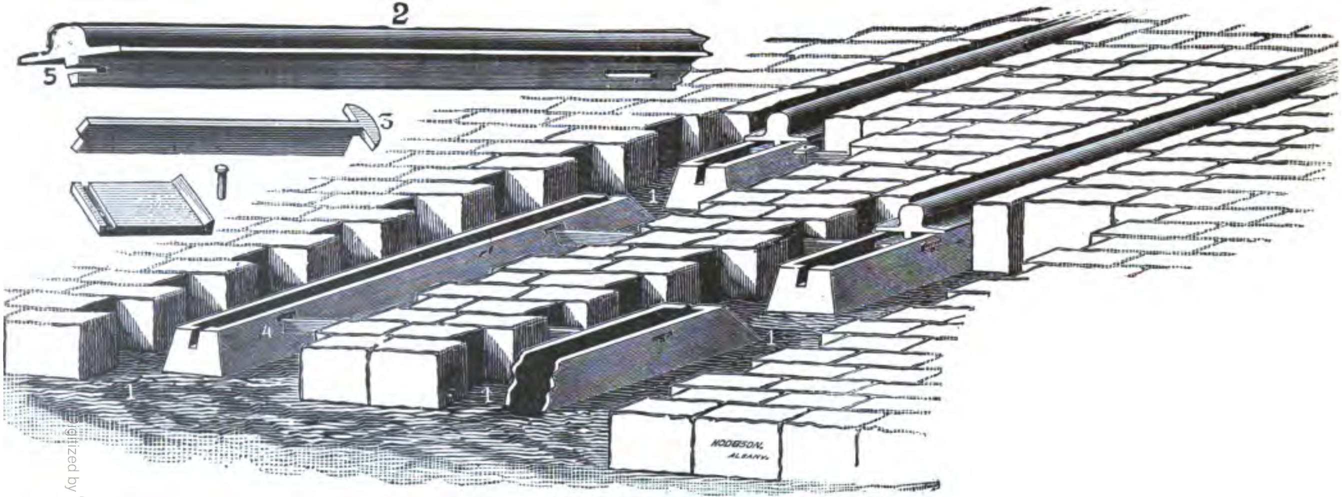


FIG. 26.

## TRACK LAYING.

In the majority of instances the municipal authorities require the tracks to be laid so as to conform accurately to the established grades, if the street be improved; if not, to be level with the adjoining surface. Street railway companies will find it advantageous to have a competent engineer to set grade and center stakes. My practice is as follows:

Having obtained the heights of grades established by act of common council and line of street, I have 3 strong oak stakes, two inches square, driven each 50 lin. ft. Two are for grade line. Their tops are driven to exact grade. One for the center of track, and the precise point is indicated by a small tack. A gang of men under a sub-foreman excavate trenches for the cross ties, he measuring with a pole 16 feet long and marking each four lineal feet. He is careful to excavate deep enough, measuring from a line which is tightly stretched from stake to stake. It is easy to *raise* a tie, but a work of time and expense to *lower* one, after stringers and rails are placed upon it. Another gang of men carry and place the stringers upon the cross-ties, and rails upon the stringers, being very careful never to have *two* stringer joints (one on each side of the track) come upon the same cross-tie, and never to have a rail joint over a stringer joint; our limit is four feet stringer joints, and rail joints must all break at least four feet, and this brings them over another cross-tie. A carpenter cuts into the stringer at the end of the rail for the joint chair, which, as above stated, is with us, eighteen inches long. He is careful to adz the surface, so that it exactly fits the bottom of the chair, and the latter bears its entire surface. He allows the chair to project one-eighth of an inch above the stringer, so that when forced into the wood by the heavily loaded street-car wheel, it will be level, as our chairs are 1½ inch deep, unless they happen to come just over a cross-tie, which should be the case about half the time, we insert, under the stringer, a strip of pine, 2″x5″x5′, to get as much timber at the rail joint, as the balance of the track. The rail possesses no vertical strength, and will not carry our loads over an opening of 18 inches without deflecting, as we find to be the case over sewer manholes.

A proper allowance is made in leaving the joints open to permit expansion; but even during the hottest weather, I allow one-eighth of an inch, as the metal in the rail "flows" under the traffic, when it is all in one direction, as upon double track roads. The ends of the rails are examined, and all not cut square across, are rejected. If these were accepted when a proper allowance has been made at the projecting end, the rail being 5 inches wide, the opening would be increased too much at the other side. The rails having been spiked, alternate holes, with countersunk head spikes, ½x½x5 in., another foreman places a straight edge upon the top of the stakes at each end of a fifty feet; or more frequently, if the grade should not be uniform for fifty feet. He then puts his eye level with one straight edge and sights across to the other on the line of each rail, first one side, then the other, and has the track raised to exact grade and lightly tamped at the ends of the cross-ties, at the stakes, and at all stringer joints. The gang then raise all the other ties up to the bottom of the stringers, tamping first at the ends, and then under the centres. Particular attention should be paid to the tamping, unless this is well and solidly done, your track must settle and get out of surface. Upon a steam railroad, so soon as the track is laid, section men are put to work and begin leveling up the track, and so continue to do year after year. Your street railroad track is put down to remain 10 or 20 years, with no opportunity to surface it up in paved streets. The ties having been well and securely tamped, another gang follow putting on the knees, two outside and two inside, upon each cross-tie. We use a Huntington gauge, which is always held at right angles. With the old-fashioned gauge, a careless workman might get it out of square, and the track would then be narrow gauge, resulting in derailment of cars or broken axles. The exact centre of our gauge is marked. The centre of the cross-ties is marked with chalk, and they are laid to line. Before the carpenter spikes on the knees, he goes to a centre stake and holding the centre of the gauge over the tack moves the stringer to the gauge. Having done this at each end of the 50 feet length, he sights along one rail and his helper fastens it to line. They then nail all the knees along that rail inside and outside, and return along the other rail, placing it to tight gauge; very little other lining is required to make the track perfectly straight. The stringers between the cross-ties are then securely tamped.

Where my tracks are laid in unpaved streets, I nail a bracket upon each cross-tie, outside of the stringer. It is 3 inches thick, next to the stringer it comes within 2 inches of the top of the rail; and inclines from the rail 4 inches in one foot. Upon these brackets, oak plank 2 inches thick and about 12 inches wide are spiked. Vehicles can then cross the track at all points, and get onto the rails; and dangerous ruts are prevented adjacent to, and along side of the tracks.

The expense of track laying varies with the amount of excavation, kind and quality of material composing the surface of the street in which it is laid, etc., etc. For instance, in a very hard macadam roadway, two hours and a half have been consumed by a laborer in digging a tie hole, when fifteen minutes would suffice for sand. I have had to dig four feet deep in places, to put my tracks to grade, and at other points, fill up the street two and three feet. All these, and many other items, cause the expense of track laying to vary between wide extremes.

Mr. T. H. Gibbon, C. E., favors me with the following estimate:

### COMPARATIVE FIRST COST OF STREET RAILWAY CONSTRUCTION.

TIMBER SYSTEM.

| Timber System. | Price. | Amount. |
|---|---|---|
| 66.88 Tons, 42 lbs. Rail | $40 00 | $2,675 20 |
| 352 Joint Plates | 50 | 176 00 |
| 6 Tons Knees | 50 00 | 300 00 |
| 3200 lbs. Spikes | 3½ | 100 00 |
| 32 M ft. B. M. Pine Stringers | 23 00 | 736 00 |
| 700 Chestnut Ties | 35 | 245 00 |
| 700 Iron Tie Rods | 35 | 245 00 |
| 5280 Sq. Yards, Taking Up and Repaving | 15 | 792 00 |
| Hauling Material | ------ | 150 00 |
| Hauling Sand | ------ | 150 00 |
| Carpenters, and Track Laying | ------ | 700 00 |
| Per Mile of Track | ------ | $6,269 20 |

Assuming the Life of Rail and Timber to be 20 Years.

| | | |
|---|---|---|
| The Cost of Renewal would be | ------ | $ 6,269 20 |
| Taking Up and Moving Worthless Dirt | ------ | 400 00 |
| | | 6,669 20 |
| Less 75 Tons Scrap Rail, etc. | 20 00 | 1,500 00 |
| Cost of 1st Renewal | ------ | 5,169 20 |
| Cost of 2nd Renewal | ------ | 5,169 20 |
| Cost of Track at the Expiration of 40 Years | ------ | $16,607 60 |

GIBBON'S METALLIC SYSTEM.

| | Price. | Amount. |
|---|---|---|
| 66.88 Tons, 42 lbs. Steel Rail | $40 00 | $2,675 00 |
| Joint Plates, None Used | ------ | -------- |
| Knees, None Used | ------ | -------- |
| 2800 lbs. Wedge Keys | 2½ | 169 80 |
| 50 Tons Metal Stringers | 45 00 | 2,250 00 |
| Chestnut Ties, None Used | ------ | -------- |
| 9000 lbs. Tie Rods | 2½ | 225 00 |
| 2500 Sq. Yards Paving | 15 | 375 00 |
| 120 Tons Hauling Material | 1 00 | 120 00 |
| Hauling Sand | ------ | 75 00 |
| Track Laying | ------ | 500 00 |
| Per Mile of Track | ------ | $6,390 00 |

Assuming Life of Rail 20 Years. Cost of Renewal would be

| | | |
|---|---|---|
| 66.88 Tons Rail | $40 00 | $2,675 00 |
| 2800 lbs. Wedge Keys | ------ | 169 00 |
| Taking Up and Repairing | ------ | 300 00 |
| | | $3,145 00 |
| Less 66 Tons Scrap | 20 00 | 1,320 00 |
| Cost of 1st Renewal | ------ | $1,825 00 |
| Cost of 2nd Renewal | ------ | $6,390 00 |
| Taking Up Old Material | ------ | 200 00 |
| | | $6,590 00 |
| Less Scrap Rails, Boxes, etc., 120 Tons | 20 00 | 2,400 00 |
| Cost of 2nd Renewal | ------ | $4,190 00 |

$3,344.20, the difference in cost of 1st renewal at 4% interest for twenty years (the life of renewal)=$7,439.84 less $4,190.00, the amount of 2nd renewal—leaves the company a balance of $3,249.84 and a new track; in other words the amount saved in 1st renewal, $3,344.20 creates funds sufficient for each future renewal, and also a balance of $3,249.84.

The amount that will be saved in the track maintenance I cannot figure, but it is safe to say that at least 50% will be saved by the removal of articles which cause the repairs.

The estimate for the Gibbon metallic system is founded upon his experience in laying the same.

Space does not permit an analysis of his estimate of renewal.

The width of the street, and municipal legislation, usually fix the distance between tracks, when double tracks are laid. With a gauge of 4 ft. 8½ inches, four feet between the tracks is a quite common allowance, but with present practice in building street cars, I prefer four and a half feet, as there is less danger of accident from passing cars.

When the street grade is level, I always incline my tracks towards the sewer-catch basin, one-tenth of a foot in each fifty lineal feet, to carry the water. It would be very difficult to maintain a pavement laid upon a dead level. The pavement outside of the railway tracks requires ditches at each curb to convey the water to the sewer inlet; and it is an advantage to give an inclination in the same direction, along the railway tracks. Otherwise, the cross section of the street will be so steep, next to the sewer inlet, that horses experience difficulty in maintaining a foothold.

The gauge of the street railway is generally fixed by law. Four feet eight and one-half inches is the most usual. In smaller towns, three feet is used. It possesses the advantage that ordinary vehicles can not follow the rails. The disadvantages; that if they run one wheel upon the rail expensive ruts soon wear into the pavement, and the horse path is narrow for two horses of average size to travel therein.

The following tables will prove useful in estimating quantities.

### RAILROAD IRON REQUIRED FOR ONE MILE OF TRACK.

| Weight per yard. | TONS | | | | Weight per yard. | TONS | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Of 2,240 lbs. | | Of 2,000 lbs. | | | Of 2,240 lbs. | | Of 2,000 lbs. | |
| Lbs. | Tons. | Lbs. | Tons. | Lbs. | Lbs. | Tons. | Lbs. | Tons. | Lbs. |
| 8 | 12 | 1,280 | 14 | 160 | 52 | 81 | 1,600 | 91 | 1,040 |
| 12 | 18 | 1,920 | 21 | 240 | 56 | 88 | | 98 | 1,120 |
| 16 | 25 | 320 | 28 | 320 | 57 | 89 | 1,280 | 100 | 640 |
| 20 | 31 | 960 | 35 | 400 | 60 | 94 | 640 | 105 | 1,200 |
| 25 | 39 | 640 | 44 | | 62 | 97 | 960 | 109 | 240 |
| 28 | 44 | | 49 | 560 | 64 | 100 | 1,280 | 112 | 1,280 |
| 30 | 47 | 320 | 52 | 1,600 | 65 | 102 | 320 | 114 | 800 |
| 35 | 55 | | 61 | 1,200 | 68 | 106 | 1,920 | 119 | 1,360 |
| 40 | 62 | 1,920 | 70 | 800 | 70 | 110 | | 123 | 400 |
| 45 | 70 | 1,600 | 79 | 400 | 72 | 113 | 320 | 126 | 1,440 |
| 48 | 75 | 960 | 84 | 960 | 76 | 119 | 960 | 133 | 1,520 |
| 50 | 78 | 1,280 | 88 | | | | | | |

### NUMBER OF RAILS OR JOINTS IN ONE MILE OF SINGLE TRACK.

| Length of rail. | Number of joints. | Length of rail. | Number of joints. |
|---|---|---|---|
| 20 | 528 | 27 | 391 |
| 22 | 480 | 28 | 377 |
| 24 | 440 | 29 | 364 |
| 25 | 422 | 30 | 352 |
| 26 | 406 | | |

### CROSS TIES PER MILE OF SINGLE TRACK.

18 inches from center to center, 3,520 ties.
20 " " " 3,168 "
22 " " " 2,880 "
24 " " " 2,640 "
27 " " " 2,347 "
30 " " " 2,112 "
33 " " " 1,920 "
36 " " " 1,760 "
42 " " " 1,508 "
48 " " " 1,320 "
54 " " " 1,173 "
60 " " " 1,056 "
66 " " " 960 "
72 " " " 880 "

## TABLE OF HOOK-HEADED RAILROAD SPIKES.—JONES & LAUGHLIN'S, PITTSBURGH, PA.

| Size measured under head. | Average No. per keg 150 lbs. | No. to lay one mile track four to a tie. Ties two feet from center to center. | Rail used, weight per lineal yard. |
|---|---|---|---|
| Inches. | | Lbs. Kegs. | |
| 5½ x 9-16 | 280 | 5,670=38 | 45 to 70 |
| 5 x 9-16 | 300 | 5,170=35 | 40 to 56 |
| 4½ x ½ | 400 | 3.960=27 | 35 to 40 |
| 4 x ½ | 450 | 3 520=24 | 30 to 35 |
| 3½ x ½ | 510 | 3,110=21 | |
| 4½ x 7 16 | 510 | 3,110=21 | 28 to 30 |
| 4 x 7-16 | 630 | 2,560=17 | |
| 3½ x 7-16 | 675 | 2,350=16 | 20 to 28 |
| 3½ x ⅜ | 890 | 1,780=12 | 16 to 20 |
| 3 x ⅜ | 1,030 | 1,540=10 1-5 | |
| 2½ x ⅜ | 1,200 | 1,320= 8 4-5 | 12 |
| 2½ x 5-16 | 1,620 | 1.000= 6 1-2 | 8 |

## NUMBER OF WROUGHT SPIKES TO KEG 150 POUNDS.—JONES & LAUGHLIN'S, PITTSBURGH, PA.

| Length. | ¼ inch. | 5-16 inch. | ⅜ inch. | 7-16 inch. | ½ inch |
|---|---|---|---|---|---|
| 3 | 2,250 | -- -- | --- | --- | --- |
| 3½ | 1,890 | 1,208 | --- | --- | --- |
| 4 | 1,650 | 1,135 | --- | - - | --- |
| 4½ | 1,464 | 1,064 | --- | --- | --- |
| 5 | 1.380 | 930 | 742 | --- | --- |
| 6 | 1,292 | 868 | 570 | --- | --- |
| 7 | 1,161 | 662 | 482 | 445 | 306 |
| 8 | -- -- | 635 | 455 | 384 | 256 |
| 9 | -- -- | 573 | 424 | 300 | 240 |
| 10 | -- -- | -- -- | 391 | 270 | 222 |
| 11 | -- -- | -- -- | --- | 249 | 203 |
| 12 | -- -- | -- -- | --- | 236 | 180 |

### STREET AND TRAMRAIL SPIKES, COUNTERSUNK HEADS.—JONES & LAUGHLIN'S, PITTSBURGH, PA.

| Size. | No. to keg of 150 pounds. | No. to lay one mile, the holes two feet apart. |
|---|---|---|
| | | Lbs. Kegs. |
| 2½ x ¼ | 2,300 | 345= 2⅓ |
| 2½ x 5-16 | 1,720 | 565= 3¾ |
| 3 x 5-16 | 1,250 | 640= 4¼ |
| 3½ x 5-16 | 1,150 | 690= 4 3-5 |
| 5 x 5-16 | 900 | 880= 5⅞ |
| 6 x 5-16 | 840 | 940= 6⅓ |
| 4 x ½ | 530 | 1,500=10 |
| 4½ x ½ | 480 | 1,650=11 |
| 6 x ½ | 360 | 2,190=14⅝ |
| 6 x 9-16 | 270 | 2,930=19½ |

### TRACK CONSTRUCTION IN SMALLER TOWNS.

In this country there are about one hundred and twenty-five street railways using a T rail, weighing from 15 to 56 pounds per lineal yard.

As a rule these tracks are not paved, and are an obstruction to a greater or less degree in the use of the street by the general public. They are cheaply laid and durable, when the traffic along them is confined to the street railway cars.

A block of wood should be inserted between the bottom of the rail and the cross tie, to get the latter deep enough to protect it from the wear of horses' hoofs and ordinary vehicles. Holes should be bored in these blocks, through which hook-headed spikes may be driven to fasten the rail to the cross-ties. The latter are spaced two to three feet between centers. Plank two inches thick of oak or pine, six to twelve inches wide, is frequently used on each, outside of the rail, to allow vehicles to cross. Blocks are sometimes fastened to the cross-tie to which these planks are spiked, so that their tops come a trifle below the rail head, or the plank rests on the bottom flange of the T rail, and is spiked to the tie.

Cedar fence posts, sawed in half, are sometimes used for cross-ties, the wide part put up, under the rail. Pine is also used, sawed 4" by 6" or 5" by 7" and 7' 0" long.

Other roads use a light tram rail, 4 or 5 inches wide, weighing from 16 to 30 lbs per lineal yard, placed on stringers, the top of which have been dressed to fit the bottom of the rail. These stringers correspond in width to the rail and are six or seven inches in depth, depending upon the pavement to be used. Sometimes they are secured to the cross-tie by boat spikes, passing through the stringer, and driven before the rail is put in place, or round iron ½ inch in diameter without head, is used. If it becomes necessary to remove a cross-tie, this construction is objectionable and a pin of hard wood is preferable.

Outside, the stringers are braced by brackets of pine, cut to pattern as before described, from plank 3 or 4 inches thick. These are spiked to the cross-tie and to the stringer, and upon them planks are fastened paralled to the rails, as above described.

I have no hesitation in recommending some type of the girder rail for all these roads where wooden stringers have been used heretofore, believing it will furnish a better track, and therefore deem further description of the present construction, superfluous.

### CURVES.

The radius of the curve is usually regulated by the width of the street.

Forty-five feet radius upon the center line is quite common. When two curves occur, a double track leaving a double track, they should not be struck from the same center! For instance, suppose we make an inside curve of forty-five feet radius. If the tracks are nine feet apart on center lines, and we make the outer curve fifty-four feet radius, striking it from the same center; if two cars should meet at one end of the two curves, the car on the forty-five feet radius curve would project fourteen inches further from the track than ordinarily, and if four feet be assumed as a safe distance, it will be reduced to two feet and ten inches, with a liability of accident.

If forty-five feet be used as the radius of *each* curve, the outside curve will not begin until a point nine feet beyond the inside point of curve shall have been passed.

My own practice is to make the inside curve with the longest radius that the circumstances will permit, and make the outside curve with a radius that will not lessen the distance between the cars. After the two cars are *both* upon the curves, even if they are struck from the same center, the distance will be the same between them, as on the straight track.

Regarding steam railroads, Trautwine wrote:

"It is assumed that the *total amount* of *extra* power due to *curvature*, and expended in running around any given curve, at any given speed, is in proportion to the number of *degrees* contained in the curve, without regard to its radius or length."

Baron Von Weber considered "that resistance due to curve increases faster than radius diminishes."

*Street Railway* curves with guard rails upon outer and inner lines are quite different from the *steam* railway curves, in the amount and character of the resistance they offer.

The longer the radius, the less the wheels bind in the groove, while the resistance is spread over a greater length of track! Cars are not strained so much nor do horses have to pull so hard at a given instant. The grade of the curve had best be level, if possible, in street railway construction. The low speed obviates the necessity of elevating the outside rail.

Over one hundred companies use grooved, rolled rails for curves, and lay them to *tight* gauge. The accompanying cuts, Nos .27 and 28, show the form of such a rail. It is laid inside and outside of curves from 28 feet to 150 feet center radius. From 150 feet to 600 feet radius I use one such rail on the *inside* of the curve, as a guard and any ordinary rail outside.

In passing around a given curve the *front* wheels of the street car usually bear against the inside of the outer rail, the tendency being to travel at a tangent to the curve. The rear wheels bear against the inside of the inner rail. The guard rail, therefore, laid on the inner curve line prevents the front wheels leaving the track. It should be extended at least eight feet on the straight track. The guard rail on the outer curve line performs the same duty for the rear wheels.

The street car having a short wheel base, usually six feet, with ends overhanging often nine feet, is quite unstable and is easily deflected from the track, the wheel flange being often only one-half inch in depth. This liability to leave the track is increased by the fact that frequently the front or the rear platform is loaded more heavily than the other. If the greatest load is on the front platform, the rear wheels are liable to leave the track, or vice versa.

Many roads consider a guard rail as unnecessary with radii exceeding two hundred feet, preferring to take the chance of the cars running off the track! Accidents are expensive! In many of the states, if a person is *killed*, $5,000 limits the liability, but in the event of serious injury, *ten times that amount* has been awarded by juries!

I, therefore, think it the part of wisdom to use guard rails, as a matter of insurance against accidents.

A few companies prefer one grooved rail for the inside of curves and a flat rail for the outside, upon which the car wheel travels on its flange.

The length along gauge lines of a curve with forty-five feet center radius turning a right angle is; on outer gauge line 892.6071 inches; on inner gauge line 803.8569 inches. The difference in length is 88.7502 inches. When both wheels are rigid upon an axle, one wheel must slide 7 feet, 4¾ inches.

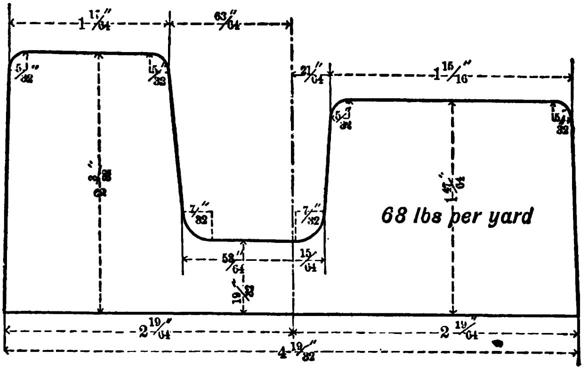


Fig. 27.

Some street railways, as above stated, to lessen this resistance, have the outside wheel travel around the curve upon its flange. The ordinary street car wheel has a diameter of thirty inches, with flange one-half inch deep. Suppose the inside wheel revolves upon its tread, having a diameter of thirty inches, its circumference = 30 × 3.1416 = 94.248". In the above distance $\frac{803\ 8569}{94\ 248}$ = 8.5 × revolutions. The wheel traveling upon its flange, with diameter of 31 inches × 3.1416 has a circumference 97.3896 inches.

In 8.5 revolutions, supposing there be no slipping, it travels 827.8116 inches. The length on outer gauge being 892.6071 deducting 827.8116, leaves 64.7955 inches or about three-fourths the distance, it has to slip when traveling upon its tread. This advantage is usually considered more than equaled by the fact that the flange, being comparatively sharp soon cuts grooves into the flat rail upon which it travels. With few exceptions all the large companies use rolled rails and cast iron curves are being abandoned. The superiority possessed by the rolled rails consists in the facts:

1. Increased length in the pieces forming the curved rails. These rails are made 30 feet long, thus offering only a quarter or a sixth as many joints, lessening the resistance and thereby saving horse flesh, cars and discomfort to passengers. Being longer, each rail contains a greater number of spikes and is thus more securely fastened to the stringer.

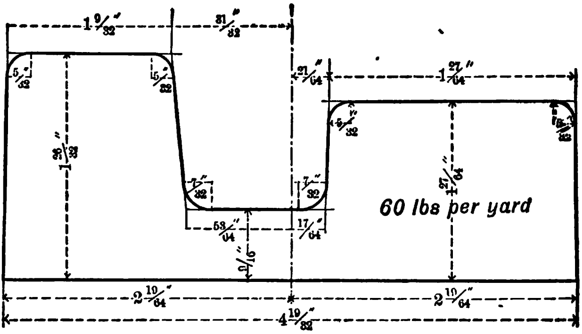


Fig. 28.

2. They weigh less per lineal foot, than cast iron curves.
3. They are more durable.
4. They can be laid more expeditiously.
5. They conform more accurately to the curve lines.

My practice is, with wooden stringers, to have pieces sawed to pattern for the curve, half the height of the ordinary stringer, eight feet long, surfaced top and bottom. I then lay these pieces, one on top of another, on the cross-ties, breaking all joints and spiking them together before the rail is put on.

Wm. Wharton Jr. & Co. possess an enviable reputation for first-class work and furnish the majority of the street railway companies of this country with curves for wooden stringers.

The Johnson Steel Street Rail Co. do similar work when a girder rail is used.

The following bill is for steel rolled curves, upon a double track turning an angle of 90 degrees from a double track road.

| | | |
|---|---|---|
| Rails curved to center radius of 45 feet, 7,300 lbs., at 3½ cts | | $255 50 |
| 1 Tongue Switch<br>1 Mate for Same<br>1 Open Point Switch<br>1 Mate for Same<br>6 Patent Crossings | 5,164 lbs., at 3½ cts | 180 74 |
| 1 Steel Tongue, 68 lbs., at 20 cts | | 13 60 |
| Drilling and Fitting | | 5 00 |
| Freight and hauling from depot | | 52 62 |
| Total | | $507 46 |

*Materials in laying said Curves.*

| | |
|---|---|
| 80 Curve Circles, dressed to pattern, 25c | $20.00 |
| 200 Knees, 19½c | 39.00 |
| 6 Composition Chairs, 75c | 4.50 |
| 8 Curve Chairs, 50c. | 4.00 |
| Spikes, $2.55 | 5.10 |
| Total | $ 72 60 |
| Total cost laid | $580 06 |

The cost of labor in laying curves is estimated at double that of straight track.

Fig. No. 29 shows a portable bending machine of Wm. Wharton's, which will be found quite a convenience.

Of course it is best for the street railway company to purchase curves complete, rather than to buy the rails and attempt to bend them to suit, for the railway can not do the work as well, nor so cheaply, as the manufacturer.

At times, however, it is necessary to bend one or more rails and such a machine as indicated in the illustration will be found better than the screw clamp frequently used.

If it should be necessary to bend a rail for a curve, the following table will prove useful. The first column contains different radii from 30 to 100 feet. The next column contains the middle ordinate, or distance measured square from half the length of a straight edge 20 feet long to the rail.

Suppose we want to bend a rail a, b, e, c to a radius of 45 feet. Looking in the column headed radius, we find 45 and opposite to it in the column marked middle ordinate we find $13\frac{15}{32}$ inches. This is the distance from B to D, that will exist between a point at the middle of the length of a straight edge 20 feet long and the edge of a rail of 45 radius. If we want another measurement at E. F. five feet from one end, we take ¾ of the $13\frac{15}{32}$ inches = $10\frac{1}{8}$ inches.

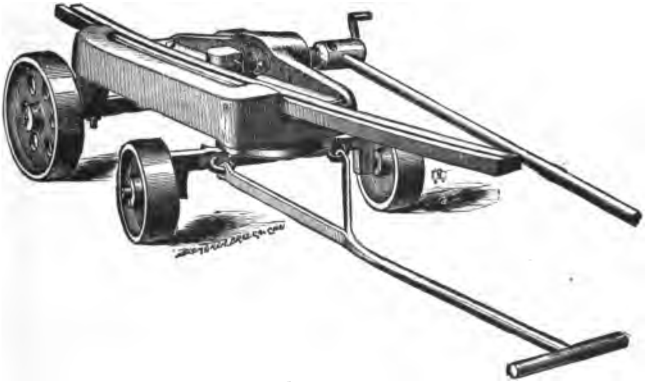


Fig. 29.

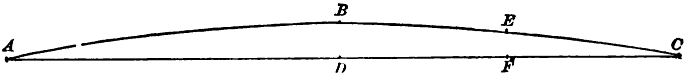


TABLE OF MIDDLE ORDINATES FOR BENDING RAILS 20 FEET LONG.

| Radius in feet. | Middle Ordinate in inches. | Radius in feet. | Middle Ordinate in inches. | Radius in feet. | Middle Ordinate in inches. | Radius in feet. | Middle Ordinate in inches. |
|---|---|---|---|---|---|---|---|
| 30 | $20\frac{19}{32}$ | 47½ | $12\frac{25}{32}$ | 65 | $9\frac{9}{32}$ | 82½ | $7\frac{21}{64}$ |
| 32½ | $18\frac{59}{64}$ | 50 | $12\frac{1}{8}$ | 67½ | $8\frac{15}{16}$ | 85 | $7\frac{5}{64}$ |
| 35 | $17\frac{33}{64}$ | 52½ | $11\frac{17}{32}$ | 70 | $8\frac{5}{8}$ | 87½ | $6\frac{61}{64}$ |
| 37½ | $16\frac{19}{64}$ | 55 | 11 | 72½ | $8\frac{5}{16}$ | 90 | $6\frac{23}{32}$ |
| 40 | $15\frac{1}{4}$ | 57½ | $10\frac{33}{64}$. | 75 | $8\frac{1}{32}$ | 92½ | $6\frac{19}{32}$ |
| 42½ | $14\frac{5}{16}$ | 60 | $10\frac{5}{64}$ | 77½ | $7\frac{25}{32}$ | 95 | $6\frac{23}{64}$ |
| 45 | $13\frac{15}{32}$ | 62½ | $9\frac{21}{32}$ | 80 | $7\frac{17}{32}$ | 100 | $6\frac{1}{64}$ |

## CROSS TRACKS.

Cross-over tracks are required, when it is necessary for the cars to pass from one line of a double track road, to the other.

I have adopted a standard cross-over with a center radius for reverse curves of 100 feet.

They should be laid, whenever it is possible, so that the switch is never opposed to the ordinary car traffic. If this is not attended to, a passing wagon, maliciously disposed person, etc. may open the switch. If the open switch escapes the notice of the driver, he is liable to collide with a car, or other vehicle, upon the adjoining track, and an accident result.

I always use grooved rails, inside and outside on all cross tracks, with guard rails at the end, on straight track, eight feet long. Fig. No. 30 is an isometrical view of such a cross-over.

Wm. Wharton Jr. & Co. make a patent crossing for curves. When one line is used more than the other, which is often the case in cross-overs, the main line tracks are unbroken, and when the rails constituting the latter are worn out, they can be renewed without interfering with the other track. These patent crossings are shown in the above cut.

Bill of items for cross-over track, having radii on center line of 100 feet. Bessemer Steel Rails, 60 lbs. per yard. Length in street from end to end, 60 feet.

| | | | |
|---|---|---|---|
| 2 Inside Rails, | Radius, 97′ 7¾″<br>Length, 17′ 7¾″<br>Straight, 9⅝″ | 1,700 lbs., at 3½ cts.... | $ 59 50 |
| 2 Outside Rails, | Radius, 102′ 4¼″<br>Length, 19′ 10⅝″<br>Straight, 1′ 9⅜″ | | |
| 1 Guard Rail, | Straight<br>Length, 10′ 0″ | | |
| 1 Right Hand Tongue Switch | | 4,220 lbs., at 3½ cts..... | 147 70 |
| 1 Mate for Same | | | |
| 1 Right Hand Open Point Switch | | | |
| 1 Mate for Same | | | |
| 2 Frogs | | | |
| 1 Crucible Steel Tongue and Pin, 77 lbs., at 20 cts............. | | | 15 40 |
| Drilling and Fitting ........................................ | | | 5 00 |
| Freight and teaming.......................................... | | | 17 76 |
| Cost of putting the above in track. Total............. | | | $245 36 |

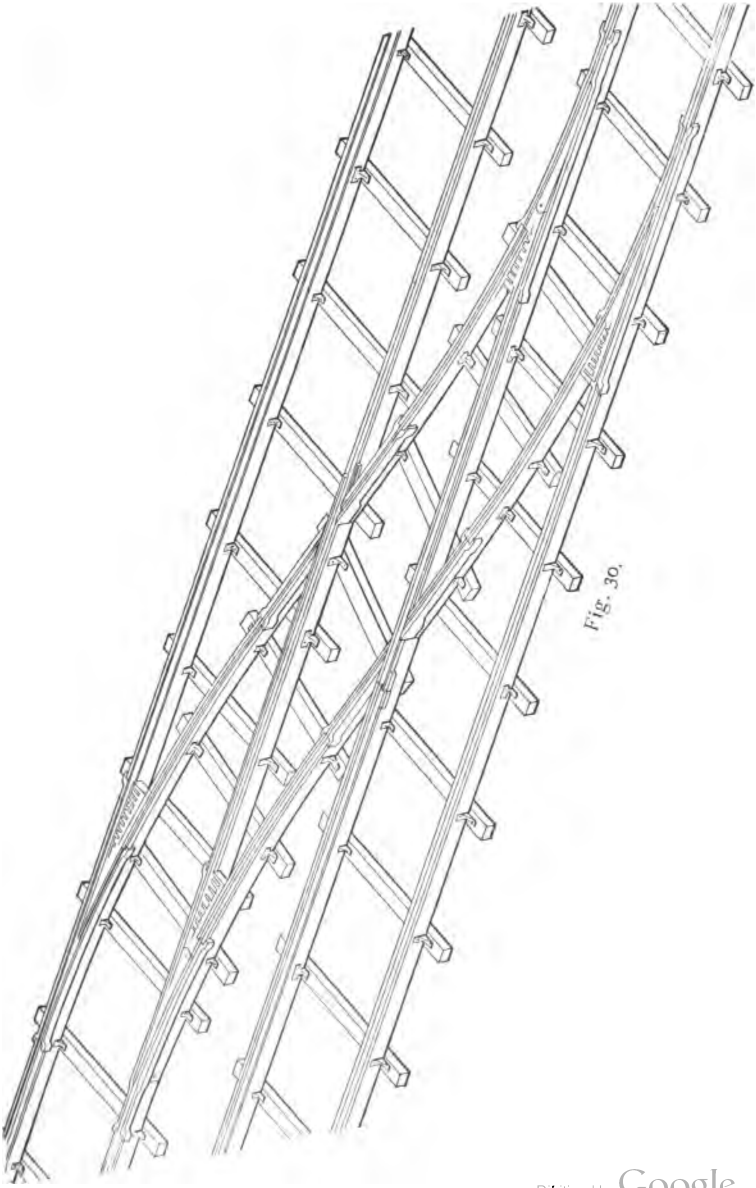


Fig. 30.

| | | |
|---|---|---|
| 1 Day Foreman, $3.50 | $ 3 50 | |
| 17 " Labor, $1.50 | 25 50 | |
| 2 " Carpenters, $2.25 | 4 50 | |
| 1 " Team, $4 00 | 4 00 | |
| 20 Curve Circles, dressed to Pattern, 25 cts | 5 00 | |
| 20 Knees, 19½ cts | 3 90 | |
| Spikes | 2 55 | |
| 1 Composition Chair | 75 | |
| | $49 70 | 49 70 |
| **Total in street** | | $295 06 |

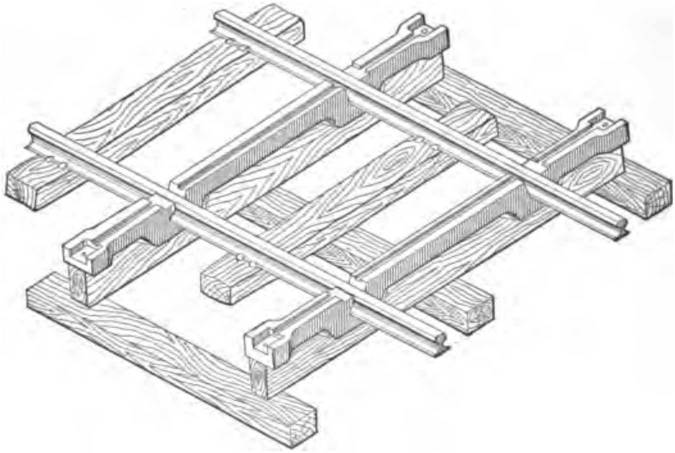


Fig. 31.

Figs. 31 and 32 give an isometrical view of a patent crossing for horse and steam railroad tracks. The latter are unbroken, and the wheel of the horse car passed over the head of the steam railroad rail.

In a case where a double track horse railway passed over a double track steam railroad the 12 castings complete weighed 18,935 and cost at 3½ cts. per pound f. o. b. Philadelphia $662.72.

Figs. 33–34 show the Johnson Automatic Switch, which I have used some years and found satisfactory. The cost of the switch, without royalty, is $225.00 f. o. b. in Philadelphia. It is turned by the weight of a horse transmitted through levers, and does not retard the car, thus saving the horse the great strain of starting.

It saves the conductor the task of jumping off his car, and running forward to turn the switch. Where lines separate, more people are apt to get on and off, than at other points, and it is very desirable that the conductor should be on his car to prevent accidents. He can keep his car and himself neater if he does not have to wade through mud to set a switch.

Some method of draining should be provided, for otherwise water is apt to congeal in the box during cold weather and interfere with its working.

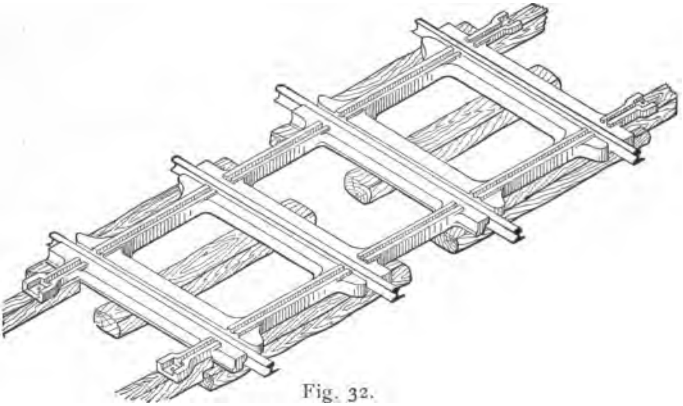


Fig. 32.

### TURN-TABLES.

Many roads prefer to turn their cars at each end of a line thus always running the same end foremost. The front platform can then be enclosed and devoted exclusively to the driver, when box cars are used, lessening the danger to patrons in getting on or off the cars.

There is always more or less danger in transferring the horses from one end to the other of a car in a crowded city street.

Figures 35 and 36 show Wharton's Cast Iron Turn-table. Turn-tables are also manufactured by Andrews & Clooney; Bowler & Co.; S. M. Carpenter; Hathaway & Robinson; Tom L. Johnson; Johnson Street Rail Co.; Maher & Brayton, etc.

The objection to turn-tables in city streets is danger to passengers who attempt to get on or off the car while turning and to people or vehicles passing in the street.

### CONTRACTORS.

Street railway companies, especially new roads, will find it more economical and far better to let the contract for the construction of their roads, to *experienced* and responsible contractors.

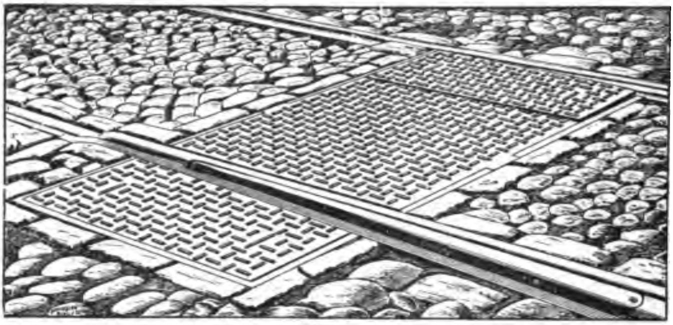


Fig. 33.

Having had twelve years' experience upon steam railroads, the majority of them as chief engineer, I began street railroad work with the impression that my knowledge would prove useful.

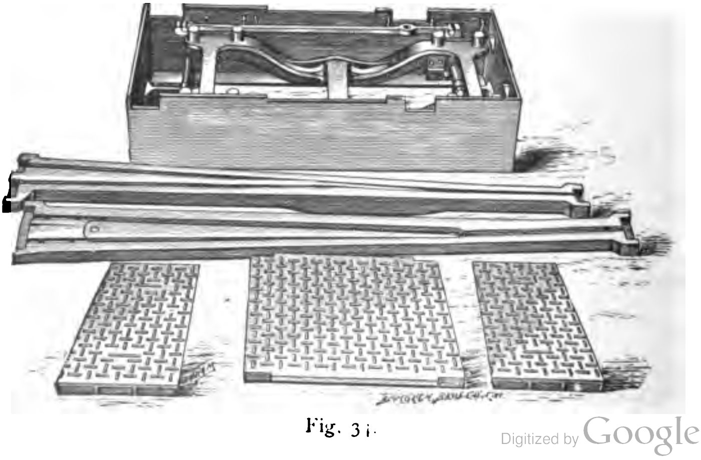


Fig. 34.

A short space of time sufficed to convince me, that the work was entirely different, and I had to begin *de novo.*

It has been largely the practice with street railway companies to build their own tracks, and the condition of many roads to-day, proves the folly of this system. Very few steam railroads find it advantageous to construct their own roads, and I am at a loss, why street railways should pursue a different policy. Instances have come under my observation where contractors of many years' experience in street railway construction have offered to do the work for new companies. The latter considered the price too high. Employed a foreman, bought material and built the road after a fashion. The results were, that they found the roads had cost more money (and were not nearly as good), as if an experienced contractor had done the work. It is assumed by these companies that any ignorant man, although he might never have seen a street railway built, could superintend *their* work, provided he did not want more than two or three dollars per diem.

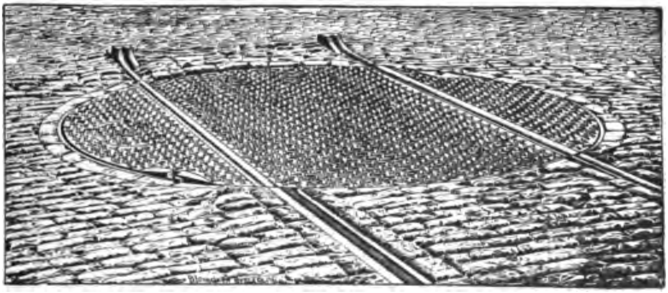


**Fig.** 35.

The lack of all mechanical skill evinced upon many a prominent street railway in its track construction is most deplorable.

I have seen tracks laid with the rail joints *directly over stringer joints.*

I have seen a common laborer employed to adz into the stringer, for the joint chair. He cut one end *half an inch* too deep, and to make the rail heads come even on top, inserted a chip of pine, between the bottom of the rail and the chair, to be crushed by the first loaded car wheel. With such work is it strange that we hear a moan "Poor tracks?"

If the contractor were encouraged, the men would be more permanently employed; in a measure his interest and theirs would be identical in doing good work, for unless he maintained a reputation for thorough construction, the contracts would be awarded to one who did, and his men would not stand the same chance for steady employment. The company would get better tracks than under the day labor system and at less cost. It is proverbial that employees do

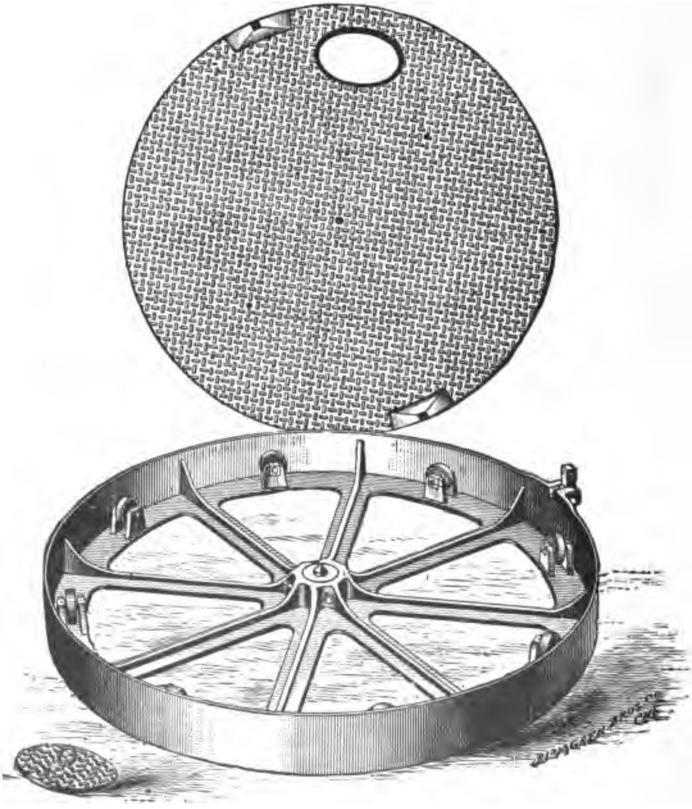


Fig. 36.

more work for an individual or a firm, than for a corporation. When engaged in track construction it is to their interest, *not* to do the most work for the least money, but to *prolong the job.* In contracting for such work, the overtaxed street railway official is relieved of all actual work, and has only to inspect the completed construction. The company knows the exact cost of the work in question, which is rarely the case under the present system.

# CHAPTER II.

## PAVING.

The first cost of paving, laid by the street railways of this country, probably exceeds fifteen million of dollars. The maintenance involves a yearly expenditure of millions of dollars!! Not only every stockholder in each company is therefore interested in the quality and kind of paving laid by the street railway companies, but also the far greater number of individuals constituting the general public, who use the pavement in common with the various street cars.

Thomas Young wrote: "There are few departments of practical mechanics in which every individual at some period or other of his life is more interested, than in the management of roads and pavements."

I shall confine myself to a consideration of the best pavement for horse railroad track.

What are the requisites of such a pavement? Clearly a suitable roughness to afford a foothold for the horse, durability, cheapness of original construction and facility with which repairs can be made.

Gen. Gilmore, considering the requirements for paving, wrote, "Roads, Streets and Pavements."

"Another consideration demanding the exercise of sound judgment is that *no pavement combines* the opposite requirements of an even surface for the wheels, and suitably rough one for the horses to travel upon, and a compromise of advantages must therefore *be made in most circumstances*." (The italics are mine.)

This is not the case with horse railways. Gen. Gilmore wrote of horse paths for street railways. "The best pavement between the rails and upon which the animals appear to travel with greater confidence and less fatigue than any other possessing the requisite firmness and durability, is one of rather small cobble stones, laid with a very slight inclination towards the rails."

The ordinary street rail provides the smooth surface for the wheels and selected cobble stone a foothold for the horses thus combining all that theory would indicate as essential in a perfect pavement. Upon this subject Gillespie in "Roads and Railroads," wrote: "When wheeled carriages are drawn by horses, the wheels should move on the smoothest and hardest surface possible, while the horses require one rough enough to give them a secure foothold, and soft enough to be easy on their feet. These two opposite requirements are united only in roads with trackways, of which two parallel tracks of suitable materials are provided to receive the wheels, while the space between the tracks is filled with a different material on which the horses travel."

James A. Whitney, in a paper read before the New York Society of Practical Engineers, stated: "To provide a pavement which will afford the firmest grip for horse shoes, and at the same time the smoothest running way for wheels, would as nearly as possible, meet the requirements of ordinary vehicles in traffic and transit on the city streets. * * * A good hold for the feet of horses manifestly permits the smoothness of the running way to be utilized to the utmost, either for speed or power applied to propulsion and also avoids the great liability to sudden and serious loss from the slipping and falling of horses upon the pavement."

The New American Cyclopedia, Vol. 13, page 192, contains the following:

"In other cities, instead of the broad, flat stones, used by the Romans, rounded pebbles called cobble stones, found among the gravel of the diluvium or along sea and river branches, have been very generally used. These when of hard stone, closely set and well rammed down in a bed of gravel and sand form an economical and very durable pavement, which gives secure footing to horses, and is easily repaired."

It seems hardly necessary at this late day to speak of wooden pavements for horse railway tracks. They are slippery and short lived.

Gen. Gilmore wrote in his aforementioned book:

"Wooden pavements made with blocks of wood, generally yellow or white pine set on the end of the grain, although they have been extensively tried in the United States and elsewhere within the past fifteen years, are unfit for streets subjected to heavy traffic. They are slippery in wet weather and are, of course, very perishable from their inability to resist the wear and tear of traffic or the course of ordinary decay."

Within my own experience, new pine block paving required repairs within six months after it was laid in the horse paths, ruts being worn into the blocks adjacent to the rails. At the expiration of eleven months an inch and a half had been worn off the surface and the entire pavement had to be replaced.

Asphalt is not used in horse paths as the surface is very slippery and dangerous, except in exceptionally dry or wet weather. Square stones 3 or 4 inches wide, 8 to 12 inches long, 6 to 7 inches deep, are used, either of granite, sandstone, trap or other tough and durable rock. The Medina sandstone has given good satisfaction, so far as wear is concerned, in some streets, but will not endure the heavy traffic of a metropolitan line. In my tracks, ruts 1½ inches deep have worn in Medina sandstone next the rails, within twelve months and they had to be replaced by granite. The sandstone affords the horses a better foot hold than the latter, which is slippery at all times, but especially so when dry.

Col. Haywood found by observation that granite was most slippery when dry, safest when wet; asphalt was most slippery when damp, safest when dry; wood was most slippery when damp, safest when dry.

I have no hesitation in recommending cobble stones of suitable size and shape, closely set and thoroughly rammed into a bed of good cement gravel, as the best pavement in general for horse paths.

The stones should be hard, preferably of granite or quartzite, water washed, say six inches deep and four inches across the horse path, by three inches wide or kidney shaped, four or five inches at their largest diameter. The stones used by me, average about twelve square inches in the horse path, and a square yard weighed 495 lbs., the average weight of each stone being 4½ lbs.

My practice is to buy the stones by weight 13,000 to 15,000 lbs. making a cord, owing to the quality of the stone. Chicago obtains the best from the Lake Superior beach. Sample sizes and shapes are furnished to pick by. They are brought in sailing vessels and are inspected at the dock. All oversized or undersized stones are rejected or bought at a less price. The balance are weighed. The price varies according to the demand and supply, from $16 to $30 per cord on the dock. Before the stones are put in the track, they are again carefully sorted. It was my practice, to lay a granite block adjacent to each rail in the horse path, alternate blocks projecting a couple of inches to afford a bond with the cobble stones. The theory was that more wear occurred next to the rail and that the heavily-loaded teams would force down the cobble and cause a rut. Experience has caused me to doubt the wisdom of this construction, for the following reasons: The granite block had an average bearing surface of twenty-eight square inches. The cobble stone about twelve square inches. The granite did not settle as much as the cobble and made a rough, slippery foot hold for the horses. I believe it would be cheaper to use all cobble, selecting the largest stones to place next to the rail. The saving in horse flesh will more than pay for the repairs.

My tracks have a firm and rigid support, and it is essential that the pavement should have an equally good foundation. I use a gravel that possesses a cementing quality. Before any paving is laid I fill the horse path with this gravel and have the horses travel over it until it is firmly compacted. If cars are not moving I put horses on and find that it is far better packed than is possible by hand ramming. The surface gravel having been loosened after the tramping, the stones are put in place, fitting them as snugly and closely to each other as possible. They are then rammed twice with a rammer weighing 50 pounds, and left level with the top of the rail, having no crown or inclination across the track, a half inch of gravel is then put on top to protect the stones until they become "set."

A paver averages fifty square yards per diem or five per hour.

When the traffic is of such a heavy character, as in the crowded down town streets of Chicago, the load brought upon each cobble stone when a truck wheel is not upon the rail forces them down and I use granite blocks, having about five times the bearing surface on the foundation; but all my granite has to be sanded after each sweeping, to enable the horses to maintain a foot hold.

The average railroad life of a car horse in this country is estimated at from three to five years.

The character of the paving, on which he travels has much to do with his length of service.

Our car horses fail from having to start a heavy load in a short time. Omnibus horses last much longer.

In a subsequent chapter upon the amount of horse power exerted in propelling a street car, I will give statistics to show that the force exerted to *start* a horse car is about *seven times* as great, upon a good track, as the force required to maintain that car in motion at a speed of seven miles per hour. *This* is the cause of our horses' brief term of service. Upon any pavement other than small cobble stone the horse slips. Upon wooden blocks in unfavorable weather we had to take off his shoes and sharpen the caulks, every *third day*, resulting in rapid hoof depreciation. If this were not done the horse was injured by falling or straining; from the latter he rarely recovered. We consider his railroad life is prolonged 25 per cent. by the substitution of small cobble stone, and shoeing so that he travels upon his *frog*. The latter is an elastic cushion provided by nature, to receive the blow and transmit it to his leg without injury to the latter. Years of experience have satisfied me of the truth of this statement, and so shod the horse will travel daily over cobble stone without injury. The increasing labyrinth of pipes in the city streets for sewers, water, gas, electrical conduits, steam heating, etc., etc., cause constant digging up of our pavement. No paving can be more readily relaid, than cobble stones.

The first cost of cobble stone pavement is not great, ranging in Chicago from $1.60 to $2.00 per square yard, varying with the price of materials, labor, the distance the materials have to be hauled, etc., etc.

In my experience during five years, on one piece containing 2672 square yards, the annual cost of repairs was 1 ¼ cents per square yard.

I selected this track because it was not dug up for sewers, gas, water, etc.

The repairs to cobble stone pavement should be constant. If one stone works loose, *put it back instantly.* If this be neglected, depreciation will rapidly ensue, for the stones are bonded each with the other. If *one* comes out adjoining stones are at once loosened and the pavement is rapidly disintegrated.

Enough has been written to convince any disinterested man that *selected* cobble stone, properly laid, combines all the essentials of the best pavement for horse railway tracks; durability, cheapness of first cost and repairs, facility with which it can be replaced after the street shall have been dug up; but above all, a firmer foot hold for the horse.

Light vehicles do not seek the tramway to the same extent as heavily loaded teams.

For general street paving, cobble stone possesses no advantages. It is utterly unfit and should not be tolerated, but for the heavily loaded vehicles, cars and wagons, who use the tramway, it offers the greatest advantages.

The following estimate gives the cost of cobble stone pavement in Chicago, the past season, for one mile of horse path, containing $2,444\frac{5}{9}$ square yards.

| | |
|---|---|
| 12 days Foreman at $4.25 | $ 51 00 |
| 48 days Pavers at $4.00 | 192 00 |
| 60 days Rammers at $2.00 | 120 00 |
| 192 days Labor at $1.50 | 283 00 |
| 102 days Teams at $4.00 | 408 00 |
| 1020 cubic yards of cement gravel, $1.50 | 1540 00 |
| 807 cords of cobble stone, $25.50 | 2057 85 |
| Total | $4.656 85 |
| Average per square yard | $1.90½ |

In this instance the material had to be hauled about three miles, and one team was used to tramp down the earth before the gravel was put in. I have tried flooding the tracks with water, ramming by hand, etc., etc., but get a far firmer foundation from the tramping with horses hoofs.

The smaller the cobble stone the more square yards they will pave per cord.

Particular attention should be paid to the gravel. Sand should not be used in its stead, for it possesses no cementing quality. The gravel should contain just enough iron loam to allow of its packing. Too much or too little are equally ruinous. If there be an excess of loam it will not stand in wet weather. If there be too little, the stones cannot be rammed to a firm bearing; the entire paving vibrates under the blows of the rammer, and the stones work loose.

In the neighborhood of Chicago, I know of only two gravel beds possessing the requisite qualities.

The rammer for cobble stone should be made of some tough, durable wood. I have used maple. Apple would be good. My rammers are turned, nine inches diameter at the bottom, three at the top. They are three feet high, with an upright handle at the top and a horizontal handle eighteen inches from the bottom. The latter is protected by an iron band, and driven full of spikes. A good weight for cobble stone rammers is 50 lbs. or about $\frac{8}{10}$ of a pound per square inch of surface.

For square stone paving the face of the rammer is made smaller.

No pine paving was laid in the city of Chicago during the year 1885. Cedar block paving, laid on pine plank two inches thick, over a layer of lake sand one inch thick, cost the city from 97 cents to $1.24 per square yard, and granite paving upon a concrete bed six inches thick averaged $4.00 per square yard during the same time.

Mr. A. G. Clarke, vice-president of the Cincinnati Consolidated Ry. sent a circular to various street railroads, asking an expression of opinion as to the best pavement for horse railroad tracks. He received replies from twenty roads, of which he states:

"With regard to the answers I received, I would say in brief that they were twenty in number, seventeen of which advised with very good reasons the use of cobble stones, as follows:

Boston, Mass., C. A. Richards, Pres. Metropolitan Ry.
Boston, Mass., James E. Rugg, Supt. Highland Ry.
Brooklyn, N. Y., Wm. H. Hazard, Pres. Brooklyn City Ry.
Brooklyn, N. Y., Wm. J. Richardson, Secy. Atlantic Av. Ry.
Buffalo, N. Y., H. M. Watson, Pres. Buffalo St. Ry.
Chicago, Ill., Aug. W. Wright, Supt. T. & C. N. Chicago Ry.
Chicago, Ill., James K. Lake Supt. West Div. Ry.
Cleveland, Ohio, H. A. Everett, Secy. East Cleveland Ry.
Columbus, Ohio, A. D. Rogers, Pres. Col. Con. Ry.
Louisville, Ky., H. H. Littell, Supt. L. City Ry.
New York City, Wm. White, Pres. D. D., E. B. & B. Ry.
Philadelphia, Pa., Thos. W. Ackley, Pres. 13 & 15 St. Pass. Ry.
Pittsburg, Pa., John G. Holmes, Pres. Citizens Ry.
Providence, R. I., D. F. Longstreet, Vice-Pres. Union Ry.
Rochester, N. Y., P. Barry, Pres. R. City & B. Ry.
Springfield, Mass., F. E. King, Supt. S. Street Ry.
Toledo, Ohio, A. E. Long, Sec. Tol. Consolidated Street Ry.
Washington, D. C., H. Hart, Pres. Wash. & Georgetown Ry.

I have given you above all the names of those who favor cobbble stones. There were four other answers.

New Orleans, La., J. A. Walker, Pres. N. O. City & Lake Ry. He favors wood, but gives no reason.

Indianapolis, Ind., P. Woodbridge, Supt. Citizens Ry. Have no granite or asphalt. Gives no opinion.

Syracuse, N. Y., R. G. Wyndkoop, Pres. G. & W. St. Ry., and Troy, N. Y., Hy. Cleminshaw, Vice-Pres. Troy St. Ry. Both like granite."

The city of New Orleans is so low and wet that it would be impossible to maintain cobble stone pavement. This is no doubt the foundation for Mr. Walker's preference for wood.

The following letter and answers were kindly furnished me by Mr. Henry Hurt, president of the Washington & Georgetown Railway.

*Statements of Leading Street Railroad Companies and Contractors, in Reference to Material for Paving Tracks.*

Office of the Washington & Georgetown R. R. Co.,
101 Pennsylvania avenue, Washington, D. C., April 17, 1876.

*Dear Sir*—What do you regard as the best material to use in paving the tracks of street railroads?

Yours truly, H. HURT, President.

ANSWERS.

Office of Citizens' Passenger Railroad Co., N. W. cor. Tenth and Montgomery Av., Phil., April 18, 1876.

*Dear Sir*—In our judgment small cobble stones make the best pavements for street railway tracks. Yours, etc.,

GEORGE WILLIAMS, President.

Office of the Second and Third St. Passenger Railway Co.,
2453 Frankford Road, Phil., April 18, 1876.

*Dear Sir*—There is nothing, in my opinion, that will equal cobble stone of small size laid in a good bed of gravel. We prefer them to any other material. Yours truly, ALEXANDER M. FOX, President.

Hestonville, Mantua & Fairmount Passenger Railroad Co.,
4300 Lancaster Av., Phila., April 19, 1876.

*Dear Sir*—In answer to your letter of the 17th inst., we would say that cobble stones are considered the most durable for use between the tracks and better for the horse than Belgium blocks.

Very respectfully, A. BOYD, President.

Office 17th and 19th Sts. Passenger Railway Co.,
Nineteenth and Master Sts., Phila., April 18, 1876.

*Dear Sir*—Yours of the 17th inst. has just been received. We consider the cobble stones, properly paved, the best material for paving the tracks of street railroads. Yours truly,

B. T. HART, Vice President.

Office West Philadelphia Passenger Railway Co.,
N. W. cor. Forty-first and Haveford Sts., Phila., April 18, 1878.

*Dear Sir*—We have found by experience that small cobble stones are the best for paving between the tracks of street railways where horses travel. Yours truly, B. F. STOKES, Secretary.

Office of the Philadelphia & Gray's Ferry Passenger Railway Co.,
22d St., below Spruce, Phila., April 18, 1876.

*Dear Sir*—In regard to paving I will say that we prefer cubical blocks on the outside of the rail, but between and on the inside of the rail we prefer cobble stones. Truly yours,
WILLIAM H. SNOWDEN, President.

Office of the Frankford & Southwark (5th and 6th Sts.),
Philadelphia City Passenger Railroad Co.,
Philadelphia, April 18, 1876.

*Dear Sir*—We find over a good bed of gravel that medium-sized cobble stones are the best footing for horses; we use nothing else.
Respectfully yours, R. FRANK ABBETT, Secretary.

Office of Green & Coats Sts. Passenger Railway Co.,
Philadelphia, April 18, 1876.

*Dear Sir*—I am in receipt of your inquiry of yesterday. I regard small cobble stones the best material for paving the tracks of street railroads. Yours truly, HY. BUDD, President.

*Dear Sir*—In reply to your inquiry regarding pavements, we consider cobble stones the best for horse paths. Yours truly,
E. B. EDWARDS, President.

Office of the Middlesex Railroad Co.,
27 Tremont Row, cor. Pemberton Square,
Boston, April 18, 1876.

*Dear Sir*—In reply to yours of the 17th inst., we would state the beach stone, known as "Kidney Stone," is the best possible paving for space between tracks of street railroads. Next to this, medium size beach stones.
Yours respectfully, GEORGE W. PALMER.

Office of the Second Av. Railroad Co., Second Av.
corner 63d St., New York, April 20, 1876.

*Dear Sir*—We find small cobble stones the very best material for the purpose named. Yours respectfully,
J. SIDNEY GOLDSMITH, Private Secretary.

Sixth Av. Railroad Depot, New York, April 20, 1876.

*Dear Sir*—I regard cobble stones of about the size of a man's "fist" as the least injurious to horses' feet, and giving them the best foothold of any pavement for the horse track of a city railroad.
Very respectfully, T. R. BUTLER, President.

Office of Brooklyn City Railroad Co., No. 10 Fulton St.,
Brooklyn, April 20, 1876.

*Dear Sir*—Yours of 19th inst. regarding paving, is received. We regard small cobble stones, with very little crown to the paving, as the best material and mode for paving railroad tracks now in use.
Respectfully yours, THOMAS SULLIVAN, President.

Office of the Broadway and Seventh Av. Railroad Co.,
corner Fifty-first St. and Seventh Av., New York, April 20, 1876.

*Dear Sir*—We consider small cobble stones the best pavements for tracks. A horse can get a better foot-hold, and they do not get slippery.

The Belgian wear smooth, and in windy and cold weather become very slippery, and we are obliged to put sand on them; they require less repairing but wear out the horses faster; a long and narrow, soft grey granite block is the next best to cobble stones. Wooden blocks are the poorest of all pavements. Respectfully yours,

J. W. Forshay, President.

Germantown Passenger Railway Co.,
Office, Eighth aud Dauphin streets, Phila., April 20, 1876.

*Dear Sir*—In reply to your favor of the 17th inst., cobble stones, medium size in proportion to cost, are the best. Granite blocks are too hard, making slippery footway. Yours respectfully,

W. M. Singerly, Secretary.

Office of Philadelphia City Passenger Railway Co.
(via Chestnut and Walnut Sts.),
4130 Chestnut St., Phila., April 19, 1876.

*Dear Sir*—Your favor of the 7th inst. in relation to the best material used for paving the tracks of street railroads, has been received.

In our estimation cobble stones are undoubtedly the best material used for paving between the tracks. The stones to be small and of uniform size, rammed level with the tracks. In starting the car with heavy loads, and on up grades, the horses have a much better foot hold.

We have tried the Nicholson, Asphaltum, Ruble and Belgian block pavements, and consider cobble stones superior to all. The Nicholson will not stand the wear but a short time. The Asphaltum in a little while crumbles up, with the expansion and contraction of our seasons of extreme heat and cold. The Ruble and Belgium blocks wear smooth and glassy, making it very slippery for the horses.

Yours respectfully, W. W. Colket, Secretary.

The Metropolitan Railway Co., President's Office,
94 Tremont St., Boston, April 20, 1876.

*Dear Sir*—I prefer for the comfort, safety and ease of the horse, the small size old-fashioned cobble stone. The horses get a better foot hold, especially in rainy weather.

In some of our streets and avenues wood pavements is used, but it is the worst thing possible for our business.

Yours truly, O. A. Richards, President.

Union Railroad Co., Treasurer's Office,
Harvard Square, Cambridge, Mass., April 19, 1876.

*Dear Sir*—We use the granite block next to the rail, and fill in with Beach cobble stone of the kidney form, and find that it enables the horses to get a better foot-hold than any other paving affords.

Yours, etc., James W. Emery, President.

Citizens' Railroad Co., Baltimore, April 22, 1876.

*Dear Sir*—We think cobble stones are much less liable to get smooth and slippery, and much more comfortable to the horse.

Yours truly, James Haggerty, President.

Office of the North Beach & Mission Railroad Co.,
San Francisco, Cal.

*Dear Sir*—We have tried every kind of pavement in our tracks that has been invented, and find the best of all is small cobble stone well put down and covered with gravel. Yours, etc.,

M. S. KELLY, Superintendent.

Office of the Grand St. Railroad Co., New York, April 20, 1876.

*Dear Sir*—Small cobble stones such as are used in Sixth Avenue railroad in this city

Office of William Wharton, Jr.,
Street Railway Constructor, Philadelphia, April 20, 1876.

*Dear Sir*—In reply to your inquiry, I will say that I consider it the best to pave the tracks of horse railroads with small cobble stone about six inches long, and set endwise, with a row of Belgian block set along side of each rail about six inches wide. WM. WHARTON JR.

Office of John Stephenson & Co.,
47 E. 27th St., New York, April 20, 1876.

*Dear Sir*—Yours of yesterday at hand with regard to material for paving track of railroads. There is nothing better than cobble stone of small size, about four inches in diameter, the shortest way placed endwise. JOHN STEPHENSON.

The foregoing opinions are those of practical, experienced men, from various widely scattered quarters of our vast country, from the Atlantic to the Pacific. They are founded upon personal observation and are worthy of careful consideration. Both theory and practice, which so often differ widely, unite in this instance and indicate that "selected cobble stones" *afford the best pavement for horse railroads.*"

# CHAPTER III.

## TRACK CLEANING.

This is a question that interests Street Railways, more especially in the Northern States where excessive falls of snow interrupt the traffic and require the greatest effort upon the part of superintendent and employés to keep the road open, to accommodate the multitudes; a greater number seeking transportation at such times, in inverse ratio to the ease with which they can be carried. The subject will be considered under the following heads:

1st. Attachments to individual cars.
2nd. Snow Ploughs.
3d. Sweepers.

### ATTACHMENTS TO INDIVIDUAL CARS.

These consist of scrapers or brooms. The scrapers are quite extensively used. Figure No. 37 shows a scraper manufactured by H. H. Littell of Louisville, Ky. It is said to be forged from the best steel and wrought iron without castings, which might break, and is easily attached to, or removed from, a street car, without cutting or disfiguring the dash. It possesses the great advantages over other scrapers of being manipulated by the driver's foot, without requiring him to remove his hand from the brake handle.

The figure shows a portion of a car to which the scraper has been attached. Hangers are bolted to the sill, carrying a transverse rocking shaft, to each end of which a scraper is securely fastened, and a cross brace inserted. Its center is extended forward, with a recess at the end in which a lever works, projecting above the car platform and worked by the driver's foot as above stated. A ratchet upon the side holds the scraper up out of the way when not in use. To prevent its being jarred over, a key is provided, chained to the dashboard, so that it may not be lost. When this key is out, the driver can apply the scrapers instantly, to remove an obstruction upon the track.

A. Day, of Detroit also manufactures a scraper. It is worked by the driver with one hand, and has been extensively applied, over two thousand pairs having been in use in 1885.

Scrapers are used, not only to remove light snow, but also mud, small stones or obstructions upon the rails. In a macadam paving, the loose stones are frequently thrown upon the rail by passing vehicles and must be removed, or the passengers are jolted, the car racked and the horse strained in an attempt to pass over it.

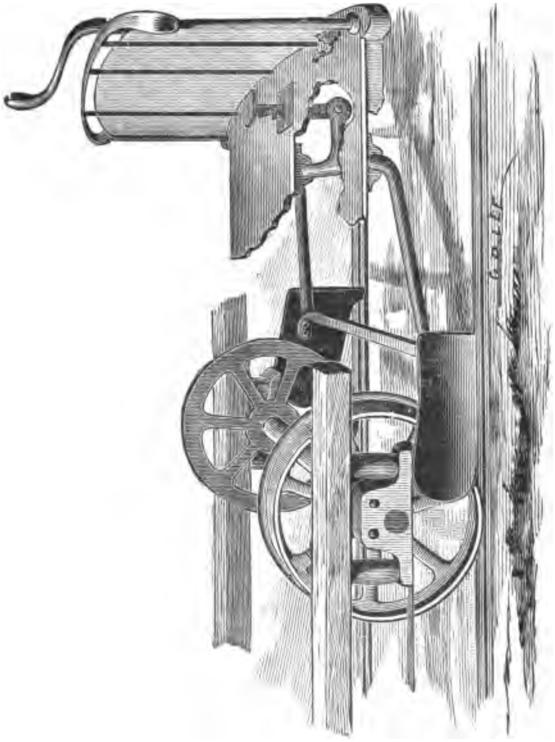


Fig. 37.

The advantages in the use of scrapers are obvious.

The disadvantages are—1st. Putting increased resistance upon the animal drawing the car. This, it is claimed is more than offset by the lessened power required upon the

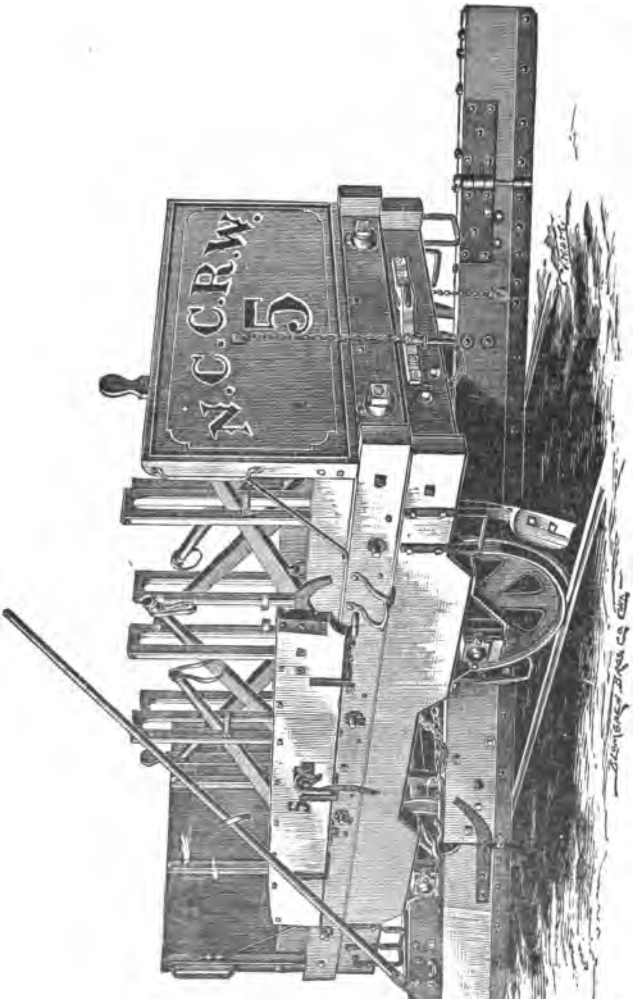


Fig. 38.

cleaned rail. 2nd. Throwing up a ridge, adjacent to each rail along its outside line. Many think that in winter weather, passengers alighting from the car are liable to slip and fall upon these ridges, resulting in accidents. A prominent superintendent who had carried probably over a hundred million passengers, upon cars equipped with scrapers, told me he had yet to hear of an accident attributable to this cause.

### SNOW PLOUGHS.

Snow-ploughs are built of various shapes and different designs, according to the locality where they are to be used and the consequent amount of snow to be removed.

Day, of Detroit, makes one, mounted upon a wagon so that it can be used along the Street Railroad track, or entirely outside. In excessive snow falls, this is an advantage, for at such times, the snow having been thrown up in ridges adjacent to the tracks, vehicles cannot either turn out or proceed along the street except upon the track, thus impeding street car travel. With such a snow plough as Day's, however, the banks on each side can be leveled outside of the tracks, when traffic will soon condense them and thus afford a passageway, removed from the rails.

Figure No. 38 shows a type of snow-plough used by the North Chicago City Ry. The frame is 6 feet 1 inch wide and 12 feet, 4 inches long of seasoned white oak and thoroughly braced. The floor is 38 inches above the track. Sills are 8 inches deep by 4 inches wide. The wooden dash at each end is 31 inches high and 73 inches wide, wheels are 30 inches in diameter.

It has eight knives of plough steel, one in front of each wheel, the plough running with either end front. Their bottoms are made to correspond in shape, to the rail head, and each is raised or lowered by a lever, as shown in drawing.

The plough proper, or scraper, is made of white oak 12 inches x 2⅝ inches x 10 feet 4 inches long, shod with iron. There are two of these scrapers, inclined at an angle of 18 inches in 24 with the line of track, passing on each side of alternate wheels. They are braced one against the other by two oak pieces 10 inches by 2⅝ inches wide, held together with ⅝ round iron rods. At the ends, additional iron braces are provided, as shown in drawing.

This frame is hung at the center of its length near each wheel-axle, by a toggle joint, so that either scraper can be lowered to the rail, or raised clear from it, as may be desired, by levers on top of the floor, as shown in drawing.

Wings are provided, from three to eight feet in length. They are easily attached by means of a hook at one end, and held in position by an iron rod 36 inches long by 1½ inches in diameter, extending to the other scraper, making a flexible joint vertically, so they can be raised to pass over any obstruction by a wooden pole, also shown in drawing. The length of wing selected to use from the several provided, is regulated by the fall of snow and the distance it is desired to throw the snow.

Four iron ladder steps, one at each corner, are provided to mount the platform. Either end runs foremost Four horses, a driver and two men are required in operating.

## SWEEPERS.

Figure No. 39 shows a sweeper manufactured by the Brooklyn, N. Y., Supply Co. Two sizes are made. The North Chicago City Railway have had one of their large sweepers, operated by ten horses, and five smaller sweepers operated by eight horses, in use for several years. They are well built. Frames are of well seasoned white oak. Floor of matched yellow pine. Sills 4x10 inches. The platform is 16 feet 6 inches long, enclosed on the sides by a round iron railing. The dash board at either end is of

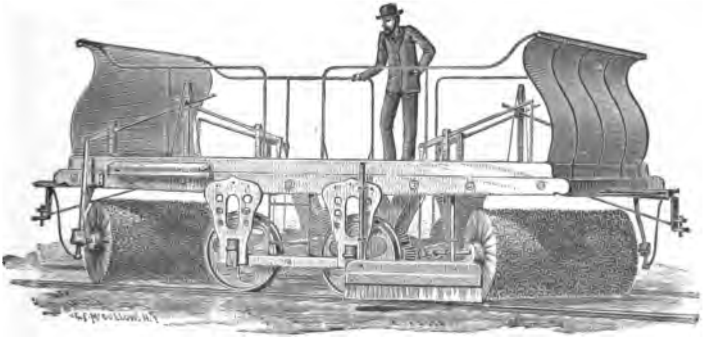


Fig. 39.

boiler iron, well braced, and curved to graceful proportions similar to a "cutter." An iron ladder is provided on each side to mount upon the platform, which is 3 feet 10 inches above the track grade. The wheels are 30 inches in diameter. Axles 3¼ inches diameter with journals 2⅜x5 inches. Near one end of the axle a strong bevel gear is keyed, and motion is transmitted from it to the brooms by a pinion proportioned two to one. This pinion is hung in a square shaft with bearings running in a frame bolted to the oak framing. Arrangements are provided so that the pinion remains in mesh with the gear whether the frame be raised or lowered. A toggle joint permits irregular motion of either broom or pinion. The outer end of the broom shaft is carried by an improved journal box which can slide up and down on a vertical shaft shown on the side of the car. It is operated by means of levers, coupled together at the center, so that both ends of the brooms are lifted to the same extent and at the same time, causing equal wear. The broom when new can be lifted several inches clear of the track and depressed until only six inches of the rattan is left.

The brooms are made of white oak; four pieces are cut to a bevel and then turned to an outside diameter of nine inches. They are retained in position by hoops of iron, and are drilled to receive twenty-four rows of rattan canes, which are bent in at one hole and out at the next. They are held tightly in place by a filling. When new the outside diameter of the rattan is 38 inches. The brooms rotate in opposite directions. As before mentioned they are geared two to one so that if the horses proceed at a velocity of six miles per hour the broom rotates at twelve miles per hour. The speed at which they revolve throws gravel, snow or mud outwards with considerable force and it has been found necessary to enclose the sweepers with stout canvas curtains. One broom would not clean both rails, so two brooms at an angle of 45 degrees are provided, and a leveling broom is also placed outside at each end.

The smaller sized sweeper is estimated to weigh about two and a quarter tons, but the actual weight has not been taken of either sweeper, owing to the difficulty of getting them upon scales. The price of either size is about $1,000 delivered in any city; but this price may be reduced in the future.

The wheels should have deep and strong flanges and run upon them, for the snow reduces the adhesion between the head of rail and tread of wheel, so that the latter will slide before the brooms will revolve, should the bearing be taken between the wheel tread and rail head.

I use eight horses for the small sweeper and ten for the large sweeper, with four men.

Fig. 40 shows the sweeper manufactured by F. H. Clooney, of New York.

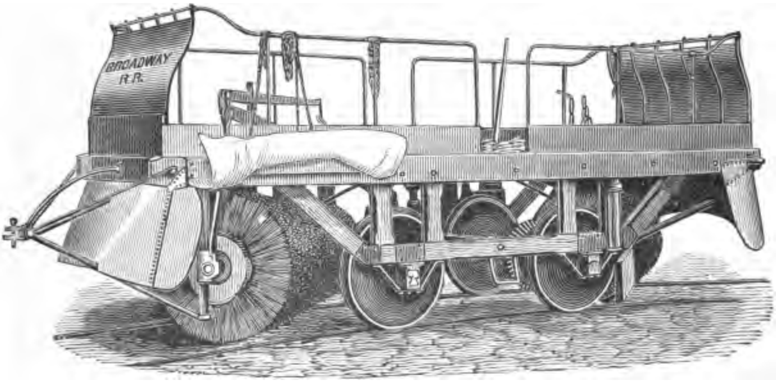


Fig. 40.

The advantages they possess over sweeping the tracks by hand are as follows:

1st. Cheapness. The cost of sweeping a track with such a machine, I have found in practice, to have been only 25 per cent. of the cost by hand power.

2d. The tracks can be cleared of snow in a fraction of the time required for hand power, even if the men can be secured to brave the storm night or day, at short notice.

This is a decided advantage, but difficult to value in dollars and cents. It enables a company to keep its road open, accommodate its patrons, save its horse flesh!!

On the other hand the pavement is swept so clean that it is more slippery than if some snow had been left upon it. This necessitates the expense of "sanding" the track each time that it may have been swept, to afford the horses a secure foothold, especially upon pavements other than cobble.

Removing the snow so clean from the pavement allows the frost to penetrate deeper than it otherwise would, thus affecting the stability of the pavement.

"Snow protects the soil in winter from the effects of cold, in the same way that fur and wool protect animals, and clothing, man. Snow is made up of an infinite number of little crystals, which retain among their interstices a large amount of air, and thus contribute to render it a non-conductor of heat.

A covering of snow also prevents the earth from throwing off its heat by radiation. The temperature of the earth, therefore, when covered with snow, rarely descends much below the freezing point, even when the air is fifteen or twenty degrees colder." The moisture from the snow is beneficial to the horses' hoofs. Without moisture they get hard and brittle.

It has seemed to me that the pavements have not been as stable since sweepers have been used as they were before. The gravel is swept out from among the interstices in cobble stone pavements. When a thaw melts the snow along side the tracks, the resulting water flows into them; or perhaps rain falls, followed in either case by a freeze. The gravel having been removed from among the interstices of the cobble, the water is more apt to penetrate and soak in beneath the stones, ruining the foundation and permitting unequal settlement. The freeze that follows raises the stones, and more extensive repairs are required. All these disadvantages should be charged against sweeping machines.

Their wheels should be made with deep flanges, as above remarked, otherwise they will have to be heavily loaded to cause the wheels to revolve, for the adhesion between the rail, covered with snow or ice, and the wheel is much lessened. The brooms are connected by gearing to the axle of the wheels, and if the latter do not turn, the broom cannot, and the snow is not removed from the track.

In my opinion, a better arrangement is to use a light, four horse sweeper behind a four horse snow plow. The sweeper could then be employed advantageously in summer to remove the mud and dirt, when it would not pay to run an eight or ten horse sweeper.

As the sweeper frightens horses along the line of the road, I always have men to accompany the sweeper, to hold such horses as appear uneasy and are without drivers.

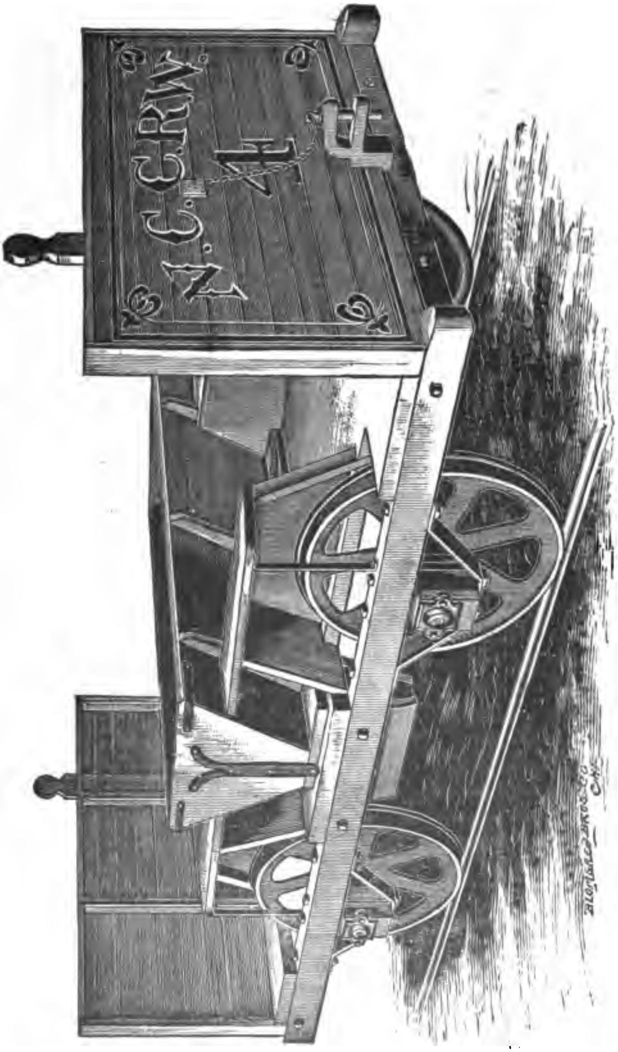

N.C.C.R.W.
41
BLOMGREN BROS. & CO. CHI.

Fig. 41.

In the severe cold of a Chicago storm, the thermometer at times sinking 25 or 30 degrees below zero, not a little trouble was experienced from the freezing of the rattan composing the brooms. This made them so brittle that they broke like pipe stems. Mr. John Miller, M. M. of the North Chicago R y, found that soaking the rattan in kerosene oil effectually prevented their freezing, and this is now always done with our sweepers.

After having been used they are put in a warm room to "thaw out," and then thoroughly cleaned, when they are ready for the next snow storm.

### SALTERS.

Fig. No. 41 shows the machine used by the North Chicago R'y. in salting its tracks. The frame is 11 feet long by 6 feet 1 inch wide. The floor is 25 inches above the track. It has a wooden dash at each end 2 feet 7 inches high and 6 feet 1 inch wide. Sills are of oak 4 inches wide and 5 inches deep. It is mounted upon four wheels 30 inches in diameter, covered as shown in the drawing.

The hopper for salt is 5 inches wide at its bottom and flares to 25 inches wide at its top, 19 inches high—all inside measurements. Over each track rail there is an opening in the bottom of the hopper 3x4 inches, with an iron sliding cover, moved by a lever on the outside, so that this opening and consequently the amount of salt dropped on the rail can be regulated at pleasure. Ten barrels of salt can be stood on the salter, and three put in the hopper. The amount of salt used upon the trip, varies with the snow fall, etc. As an average I should say the North Chicago R'y Co. use about one bushel of salt per mile of single track, and in my opinion it is not only not injurious to the horses, but a great benefit by lessening the amount of force they must exert in propelling the street car.

The use of salt upon the tracks of the street railways has awakened much discussion *pro* and *con.* Legislatures have enacted laws prohibiting its use, as detrimental to public health, but eminent physicians have expressed an opinion quite the reverse.

The special committee on "Track cleaning and the removal of snow and ice," reported to the Am. Street R'y Association, October, 1884, "that they had addressed a circular letter to the presidents and superintendents of all the street railways in America, comprising a full series of questions in relation to the propriety of the use of salt in the cleaning of the tracks from snow and ice, and whether any better method could be suggested. The inquiry was very explicit, being intended for an exhaustive consideration of the subject. Almost every individual addressed replied, making a vast accumulation of evidence bearing directly upon the subject. The conclusions appear to be decidedly in favor of the free use of salt, even to a greater extent than is anywhere practiced." A. B. Whitney, M. D., was chairman of this committee, whose conclusions were:

"The committee find that the use of salt for the removal of snow and ice from the railway track to be an imperative necessity, and that there exists no reasonable cause for apprehension of injury or detriment to the public health, or to the health or physical comfort of the animals employed. * * * It is in every way advantageous, and to this conclusion the good sense of our people must eventually arrive."

The report of the third annual meeting of the Am. Street R'y Association contains much valuable matter bearing upon this question, and enough to convince any impartial mind that this use of salt is advantageous.

Horses in Chicago are stood in a bath of salt water stronger than the brine upon the street caused by melting snow and ice with salt, because the effect is considered beneficial to their hoofs.

The testimony of street railway officials at the convention was almost unanimously in favor of the use of salt.

# CHAPTER IV.

## EQUIPMENT.

### BUILDING OF CARS.

From time to time the officials managing street railways are required to consider the matter of erecting shops in which to build their own cars, and I have been frequently asked, "Do you think it advantageous for a Street Railway Company to build its own cars?" My answer has always been in the negative, founded upon the following reasons.

A Street Railway Company is organized to transport passengers, and the more nearly it confines its efforts to this purpose, the better.

Mr. M. Kirkman wrote: "In the operation of railroads, the objective point of endeavor is the revenue that accrues from the business transacted. It is for this that the proprietors contribute money for the construction of railroads; it is for this that they are operated."

Macaulay recognized this fact when he wrote: "Now, reasoning from analogy, we should say that these great corporations would, like all other associations, be likely to attain their end most perfectly if that end were kept singly in view."

It will be conceded that railways are not organized as manufacturers, yet in Illinois one-fifth of the total number of employees are shopmen and machinists upon the steam roads.

My friend Wm. K. Ackerman, ex-President of the "Illinois Central," operating over 2000 miles of road, contributed a most valuable paper to the *North American Review*, Dec., 1884, the result of his many years' experience and observation in divers positions, having been auditor, treasurer, president, etc., upon steam railways. Regarding the subject now under consideration, he wrote as follows:

"The establishment and maintenance of large and expensive manufacturing works by railway companies is, I believe, likely to be discontinued. Railway companies were not organized for the purpose of manufacturing, but for the special object of transporting merchandise and passengers. This is their particular business, and to this end the efforts of their managers should be specially directed. A manager charged with the care and responsibility of a railway can not afford to have his attention diverted from his legitimate vocation; he has in fact little or no time to give to the supervision of a manufactory. In the early history of railways, before large and reliable establishments for manufacturing railway equipments and supplies existed, there was doubtless a necessity for each company to control its own manufactures in order to ensure thorough workmanship anp proper materials; but with the facilities now offered throughout the United States by organizations, incorporated for the express purpose of furnishing the railway companies with rolling stock and other supplies, there seems to be no longer any necessity for the railways to maintain such extensive shops. Smaller shops, with largely reduced forces, are all that would seem to be required for ordinary repairs. Before the war of the Rebellion, almost every sugar-planter in the South considered it necessary to maintain a mill on his plantation to grind his own cane. It would have been as reasonable to expect that every farmer in the North should have his own grist-mill to turn his grain into flour.

"At present in the South, under the new order of things, one sugar mill accommodates several planters, and so in regard to the railways; even one repair shop conveniently located, might be made to answer the requirements of two or three lines, and in this way, by a kind of co-operative system, the cost of even running repairs could be reduced to a minimum. But as regards new work there can be no question that it can be done now as effectually, with greater facility, and at less cost, outside of the average railway car shops. I know this does not harmonize with the views entertained by the master mechanics and master car builders; it is quite natural that it should not, but when the question of feasibility comes to be determined in the interest of the shareholders, I do not imagine that these gentlemen will be consulted. The practical effect of the railways employing some such outside agency would be to reduce materially their working force, and in this way diminish the labors and anxieties of their managers. Nearly one-fourth of the entire force of employees on our large railways are engaged in manufacturing and repairing, and in most cases they labor under great disadvantages, and are subjected to great inconveniences, both by reason of the disposition of this force, and the character of the tools and appliances."

These opinions are worthy careful consideration.

A company investing its capital in shops and machinery with which to construct its own cars is, presumably, actuated by a desire to increase its profits, and consequently its dividends to stockholders.

The principal reasons advanced for this policy are either that the company can build *better* cars for the same money, or as good cars for *less* money.

In my opinion this is a mistaken idea, and if the truth were known, the companies would find it to be so, after having invested thousands of dollars in expensive plants.

I do not believe it to be to the pecuniary interest of any street railway to enter the domain of manufactures, and compete with individuals or firms in the building of cars.

When a company launches out into car construction, what is the result?

It is not at all probable that the president or superintendent has had any practical experience in this line of business. He therefore looks about and employs a man as master mechanic, to whom is intrusted the supervision of this department. The latter receives a fixed salary, and has no pecuniary interest in the result other than to maintain his position. He has much to contend with.

It is proverbial that the laboring classes work harder for firms and individuals than for railway companies; supply men charge the railway company a larger price for the same article. The master mechanic is human. If he was personally interested in the result of his work and every cent paid out was from his *own* pocket, can anyone doubt that he would make greater efforts to reduce the cost?

The individual or firm engaged in the business of manufacturing cars *has* this direct pecuniary interest in watching every detail. He has a reputation to establish or maintain for first-class work, and competition will ordinarily preclude excessive profits. As years roll by he accumulates a wealth of experience from his extended practice. He has employees, engaged perchance for years, working hour after hour, day after day, week after week. and month after month on the *same work*, this service having extended within my knowledge upwards of *twenty years*.

The importance of this fact as regarding the amount of work done and consequent cost thereof, has been commented upon by every writer on political economy from

Adam Smith down to the present day. Over half a century ago Charles Babbage, the eminent English mathematician, wrote:

"Perhaps the most important principle on which the economy of a manufacture depends is the *division of labor* amongst the persons who perform the work. . . . A certain quantity of material will be consumed unprofitably or spoiled by every person who learns an art, and as he applies himself to each new process, he will waste a certain quantity of the raw material or of the partly manufactured commodity. . . . Another source of the advantage resulting from the division of labor is *that time is always lost from changing from one occupation to another.* . . . The constant repetition of the same process necessarily produces in the workman a degree of excellence and rapidity in his particular department which is never possessed by one person who is obliged to execute many different processes. This rapidity is still further increased from the circumstance that most of the operations in factories where the division of labor is carried to a considerable extent, are paid for as piece work. . . . When each process, by which any article is produced, is the sole occupation of one individual, his whole attention being devoted to a very limited and simple operation, any improvement in the form of his tools or in the mode of using them is much more likely to occur to his mind."

The equipment of a street railway is comparatively limited, inasmuch as no single company needs new cars enough to warrant an investment in buildings, with improved labor saving machinery, equal in extent to any of the large firms engaged in this business; and without this improved machinery, convenient and extensive shop room and arrangement, it can not compete in the manufacture.

As a matter of fact what president or superintendent of *any* street railway building its cars, *knows what they cost?*

The master mechanic perhaps attempts to keep an accurate account of the labor and material consumed in building a new car. The result indicates a saving, but he has neglected to add to the naked labor and material expenses incidental to the running of a shop, such as taxes, interest on the cost of plant, wear and tear of tools and machinery, interest on investment in supplies, etc. A recent well informed writer estimates these expenses at from 60 to 100 *per cent of the cost of the labor itself.*

It is well nigh impossible for the master mechanic to keep an *accurate account* of the cost of constructing a car.

In building a locomotive one of the leading firms require a list to be filled out under 429 *heads*.

The Car Builders' Dictionary illustrates 136 parts entering into the construction of a street car. In an accurate account this would be doubled by labor, etc. Does any street railway company keep such an account? Without it they do not and can not know the cost of car construction. The balance is all charged to the repair account. This causes the master mechanic to neglect repairs upon the cars running on the road, to keep shop expenses as low as possible.

In his report to the president or superintendent he gives the total running expenses of the shop, ignoring taxes, insurance and interest on the investment. He credits this account with the construction of a certain number of new cars, charged at a price less than the amount asked by car manufacturers for a similar car. The balance is charged to the repair account, and divided among those cars that may have passed through his shop. There is no check upon this account, for what general officer knows how much his repair account would have been without any new contruction? He can not compare the expense of repairs per car with another company's account without personally examining the condition of each car upon both roads. The one road, without building new cars, may have expended more on repairs per car. This will, of course, show in the condition of its rolling stock, but bare figures will fail to indicate this difference.

The only real saving is in the matter of freight, if the manufacturer is not located in the same place.

I speak from experience when I affirm that as good cars in each and every respect can be purchased from the manufacturer as are or can be made by any street railway company in its own shops.

As a rule, it is best to maintain repair shops, and as work therein is apt to vary from time to time in amount, it is no doubt the part of wisdom for a company to build for its own use "open cars" when such are used (their construction is more simple, less complicated than that of "close cars") to retain its skilled labor and give it employment, when otherwise the men would have to be laid off, and might make other engagements; but one or two such cars would probably bridge over the slack times of twelve months. I might enlarge upon this subject *ad infinitum.* It is a matter of great importance to street railway companies, and to such as have not built cars I would say, consider well before entering into active competition with the manufacturer

## CARS.

Fig. No. 42 shows the first car built for a street railway.

It was modeled after stage coaches, a construction also followed in building the first passenger cars for steam railroads. This car was named "John Mason," in honor of the then president of the New York and Harlem R.R., which was operated within the city limits of New York by horse power, and was the first street railroad. It was opened in 1832. The next street railroad was not built until twenty years had elapsed. It was the Sixth avenue of New York. John Stephenson built the "John Mason" in 1831, over half a century ago, but he is still at the head of a great business with the accumulated wealth of an experience gathered during fifty-five years.

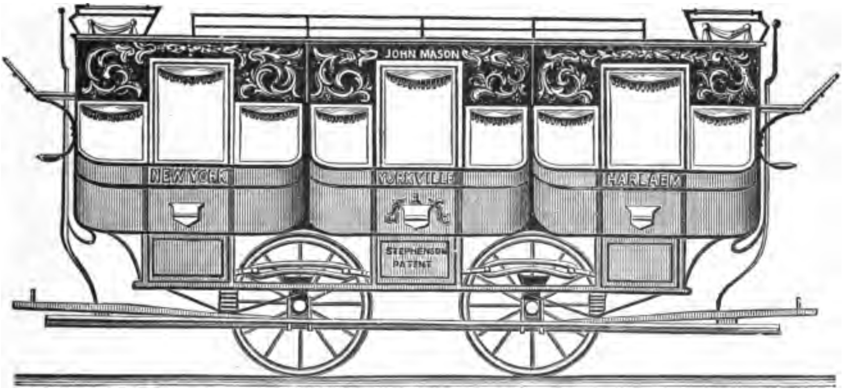


FIG. 42.

In Brown's interesting history of "The First Locomotives in America," will be found an account of the first street railway accident, which occurred, as a matter of course, upon the first street railway. "The driver of the

'John Mason' was a well known knight of the whip, Lank O'Dell, who always drove a pair of gray horses. The first trial, or experimental trip, was a most important affair in New York. The road commenced about Prince street and the Bowery, and extended to Harlem Bridge. On this occasion the streets along the route were crowded with spectators. Two cars were ready for the occasion, Lank and his grays taking the lead, with the beautiful pioneer car, 'John Mason,' and occupied by the Mayor and members of the City Council, while the second car, driven by a hack-man (his name not now remembered) and filled with some of the city officials and invited guests, brought up the rear. Great apprehensions were expressed by some of the passengers and many of the spectators, that the trouble would be in bringing these cars to a standstill at any desired point to avoid any accident that might occur in the crowded thoroughfares of the city.

"An old citizen, who witnessed this first experimental trip, related an incident that occurred on the occasion, which, though it resulted in nothing serious or fatal in its consequences, must have been ludicrous in the extreme.

"The vice-president of the road, Mr. John Lozier, being very desirous of removing all apprehensions from the minds of the doubtful, and anxious to exhibit the great facility with which the cars could be brought to a dead halt in an instant, when running at full speed, and all danger of collision with vehicles in the street rendered impossible, determined on an experiment.

"He posted O'Dell and the hack-driver of the second car to watch him, and look out for the signal, and, inviting a number of spectators to witness the experiment, he placed himself somewhere about the corner of the Bowery and Broad street. As the first car approached, he raised his arm and gave the signal to stop. O'Dell, who with his grays, had some previous practice while hauling materials in the construction of the road, performed to the admiration of the spectators, and had just come to a halt when the second car approached rapidly. The vice-president gave the signal to stop, but the hack-man, unpractised in the duty, forgot the lever (the brake), but drew hard his lines and shouted 'Whoa,' but too late—the tongue of his car went crashing through the rear of the 'John Mason,' and the Mayor and City Council beat a retreat in double quick time and in disorder from the dilapidated car, amid the laughter of the surrounding spectators. The danger over, and nobody hurt, the excursionists resumed their seats, and the cavalcade proceeded on the way toward Harlem bridge, where it arrived, without any other accident, in an incredibly short time."

This is the first street car accident on record, and was the subject of amusement to the citizens for several weeks, and a source of great annoyance to the vice-president, especially when some wag among his acquaintances, on seeing him afterward approaching on the street, would assume his position and personate his action, by giving the signal for him to stop.

Did time permit, I would fain dwell upon the importance of the action of those New York men. Of the mighty results that have sprung from their example, the millions of dollars now invested in the street railways of this and other countries, the good return upon the capital invested, its beneficial effects upon property and general business interests, the employment it affords to many thousands, its convenience to the public, etc., etc.

In purchasing cars for a street railway many important facts merit consideration—the size, shape, finish, etc., etc. The cost varies from $500 to $1,500 per car, due to the foregoing reasons.

Street railway traffic depends very largely upon the frequency with which cars pass along the line. Many a would-be patron starts to walk if the car is not in sight, and has progressed so far that he will not enter the car when it overtakes him. Excepting the metropolitan lines, where the traffic is heavy, I favor the use of a small car. At nearly the same running expenses to the street railway company, double the number of cars can be provided for the use of its patrons, resulting in largely increased revenue, and convenience to the public

John Stephenson, speaking with the accumulated experience of half a century, stated in a letter to the *American Railroad Journal*:

"No. 47 East 27th st., New York,

"January2, 1883.

"GENTLEMEN,—We regret to see that the *American Railroad Journal* is misleading the public regarding the use of small tram cars. You say the popular prejudice is strong against them 'every where.'

"The best statistics and sources of information accessible to us shows that in the United States and Canada there are about 428 tramways, of which Canada has about a dozen. Of these 428 roads, 279 are operated with small ('bob-tail') cars, and 149 are operated with large (conductor) cars. A reference to our order book for the year 1882 showed that two-thirds of our orders were for small cars. The small car system is a boon to the public, because: (1), Tramways accommodate the public when otherwise they could not exist; (2), The accommodation is better, because usually three small cars are used successfully when the effort to sustain two has proved a failure; (3), Economy of time equal to fifteen to twenty per cent., because the small cars make fewer stoppages, and being lighter, are stopped and put in motion more quickly; and (4), Merciful to horses. Two horses seldom start in unison. In the bob-tail car the one horse easily does the work, with better footing in the track."

The chief objection heretofore urged by the public against the use of the "bob-tail" car has been the trouble of depositing the fare in a box, at the forward end of the car. By the invention of a fare conveyor, Mr. Small has obviated this difficulty if the passenger is provided with the exact change or ticket. He or she can then place the amount of their fare in the conveyor with as little trouble as to hand it to a conductor, without leaving a seat. The "Small Conveyor" consists of metal tubes fastened to each side of the car, extending from the rear platform into a "fare box" at the front end of the car. The top of the tube contains an opening its entire length. It is inclined from the rear to the front, so that a piece of money or a ticket of vulcanized rubber, or any hard material, acted upon by gravity, will roll forward into the fare box.

Before this invention came into use the passenger had either to walk to the forward end of the car and deposit the fare in the box, or ask fellow passengers to pass it forward, frequently to their disgust and inconvenience.

It was more or less difficult, especially for ladies, to maintain an equilibrium in the moving car. Frequently some tender "corn" was tramped upon in the effort, resulting in curses, not loud, but deep. While the passenger was taking his fare to the box some one else would frequently take his seat. All this is a thing of the past.

The advantages offered by the use of a small car, without conductor, have been clearly set forth by Mr. Stephenson. The daily saving to the street railway company is considerable, and may be approximated as follows:

DAILY ESTIMATED COST OF RUNNING 18 HOURS.

| *One-horse Car.* | |
|---|---|
| 5 horses @ 50c | $2.50 |
| 1½ driver @ $1.75 | 2.62½ |
| | $5.12½ |

| *Two-horse Car.* | |
|---|---|
| 10 horses @ 50c | $5.00 |
| 1½ driver @ $1.75 | 2.62½ |
| 1½ conductor @ $1.75 | 2.62½ |
| | $10.25 |

Showing an economy of 50 per cent. in daily operation. If the same number of cars are run, there is a further saving in the interest on the amount of capital invested in the larger and more expensive car, and the additional horses, stable, etc.

The use of the fare-box offers an additional advantage, inasmuch as the receipts are not handled by the driver or conductor, and less opportunity exists for peculation.

The majority of street railways, therefore, find it largely to their pecuniary interest to use "bob-tail" cars until their traffic increases to a point demanding a larger car, in their opinion. My own notion is, that many roads now running large cars, would have found it advantageous to run "bob-tail" cars, but having once used the large car and conductor, they can not change. The public demand, day by day, more and more from the street railway companies. Whether or not the company may be returning a fair profit on the capital invested, is the least of its consideration.

When the climate is so severe as in our northern latitude, and the cars are unheated, the door should be opened as little as possible, and some means should be provided by which streets could be announced by the conductor without opening the door. A slide in the door, or speaking tube, or something of the kind, would serve a useful purpose.

As the box car is not usually used in summer, it should have a closed back, without perforations. Owing to the difficulty of cleaning upholstered seats. I am inclined to favor the use of a carpet, extending up to the top of the back of the seat and down in front. It can be readily removed and cleaned so often as may be necessary. The space between the floor of the car and the bottom of the seat should be closed, to prevent the drafts of cold air that otherwise strike the backs of passengers' necks, whenever the door is opened. The windows ought to be securely closed during the winter, and ventilation otherwise provided for. Everit's sash is a good invention, preventing the rattling of windows.

Castings should be provided upon the top side of the car, for carrying banners announcing attractions to invite patronage. Pins should likewise be placed on the top sides and ends of roof, for signs announcing the route of the car.

Strong eyes should be provided at each end of the car, by which to hitch an extra horse, if grades require the use of such an animal, otherwise he is hitched to the dash-board, straining it.

### OPEN CARS.

A style of car denominated "open car" and designed for warm weather has come into quite general use.

I am of the opinion that the increased revenue due to the superior comfort offered by this type of car during hot weather, thereby inducing patronage that would not have sought transportation in a "close car," does not warrant the increased cost incurred. About 75% more capital is invested in cars, when the open-car is provided in addition to the "close-car." The amount of room required in the car house is doubled, taxes and insurance are increased, and an expense is incurred if a rain or other storm requires a change during the day to the close cars, affording passengers better protection. The custom having once been inaugurated in a town must continue, and it would be useless to argue further as to the advantages or disadvantages.

The "open car" is usually entered from the side, a step being provided the entire length of the car and platforms, on each side for ingress and egress.

The liability to accidents is largely increased by this construction. With a "close car" the company cautions its patrons to enter and leave via the *rear platform*. In this event if he or she should slip or fall, it occurs *behind* the car wheels, whereas upon an open car the danger of getting under the wheel is largely increased. The records will bear me out in the statement that a larger percentage of accidents occur upon "open cars" than upon "close-cars."

Open-cars are made with stationary and also with reversible seats. My experience causes me to prefer the former.

Some people endure discomfort in riding backwards, and as a rule the seats facing forward are the first occupied, but the space that can be afforded between the seats, being limited by the length of the car, passengers can get out from the center of a seat with less inconvenience, when they face each other, having more room, than with reversible seats, and the car has less carrying capacity.

Ladies object having to crowd past men, or the reverse, in the limited space afforded with reversible seats.

## HEIGHT OF DRAWBAR.

The height above grade at which the horse is attached to the car, affects the amount of force he must exert in producing motion, moving the car forward. The point at which a horse is attached to a car, should be higher than upon a wagon or other vehicle. The reason is obvious. In pulling a load upon any surface other than a railroad, the wheels encounter obstructions of greater or less height. The horse must therefore be hitched to the load at such an angle, with traces inclining *upwards*, that a portion of his force is exerted, not in producing motion, but to the best advantage in *lifting* the load over obstructions. Now these obstructions are not assumed to exist upon a street railway, for the tracks are supposed to be laid to a uniform line. If this be true, the horse, having no obstructions over which to lift the car and its load, should be so attached to the car, as to exert all his force in producing horizontal motion, and none in lifting. Clearly, his line of draught, in this event, should be nearly horizontal.

Suppose, for illustration, that he was so attached to the car that his pull would be entirely vertical. *All* his strength in this event would be exerted in lifting the car up off the track. No horizontal force could exist, and the car would not move forward.

Cars measured by me were found as follows: Box Car had the drawbar 25½ inches above the track. Open Car 30 inches. I measured half a dozen horses of average height and found the distance from track to tug attachment upon hames to be 52 inches, and the distance along the tugs from hames to draw bar to be with circular evener 97 inches, with straight evener 90 inches.

In the accompanying diagram (Fig. 43) let A represent the draw bar to which the horse is attached. Let B represent the point at which the tugs are fastened to the hames and E F the grade or level of the track on which the horse travels.

If we figure for a "Box Car," with straight evener, the length along the line A B is 90 inches. The height B F is 52 inches. The height A E or C F is 25½ inches. This subtracted from 52 leaves 26½ inches, the height B D. This divided by the length gives $\frac{26.5}{90}$ =.2944, which is the sine of the angle B A C, about 17° 7′. The cosine is .95566 which subtracted from 1.00000 leaves .04434 the versed sine, or C D.

Now if a horse is pulling 200 lbs. 4.34% is exerted in

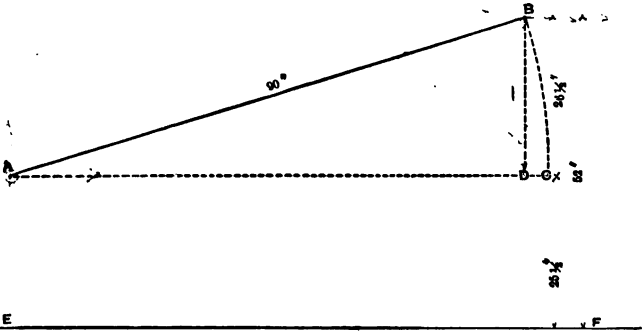


FIG. 43.

*lifting* the car, (8.68 lbs.); not in producing motion. Upon entering a grade rising 6 inches in the above distance, 6.747% of his total force exerted would be lost.

The most advantageous height at which to attach the horse to the car, therefore, *considering the line of draught*, is level with the point upon the hames, to which the tugs are attached. In a hard pull the horse throws himself forward against his collar, and this height is lowered probably 4 to 6 inches. It is evident that the heights of the horses vary, and an average height must be adopted.

Should the point at which the horse is attached to the car be *higher* than the tugs at the hames he will exert his power at a greater disadvantage, than when it is the same distance too low, for on the last assumption he is lifting up a portion of his load, but in the first case actually adding to the load by the downward pressure.

Mr. Pugh, of the John Stephenson Co., happening to be in Chicago, the above was submitted to him and he requested permission to show it to Mr. John Stephenson. The latter wrote as follows:

"Our Mr. Pugh has put in our hands your dissertation ~~on the~~ height of draw bars for street cars.

"It is a subject of ~~great importance—is not well under~~stood, and errors expose to serious practical evils. In fact it is a case where 'science' without practical experience will mislead.

"I have read carefully your article, and hope it will not be given to the public in that form, for it may do you harm professionally, while leading some astray.

### "HORSE SERVICE

"The most severe part of the horse car service is in the frequent starting of the car, in doing which he wrings himself, slips, and falls. He falls because he slips, he slips because his feet do not hold their grip to the pavement. The angle of the trace adds to, or diminishes the grip, and, with the low point of draft, lifts the load while increasing the foot grip; doing what (or more) an experienced teamster does when his horse is on a strain, i. e., mount on his back to give him more weight, and therefore, better footing. An old and expert teamster, if he is going to haul a log, will bring his horses close up and get his chain at the underside of the log—or if a stone boat is to be moved, the horses will be brought close up to the work; in all these cases securing the footing while lifting the load.

"Again. The horse is made with his shoulder at an angle, so that the trace must be low at its back end, and even at a lower point than a right angle with the shoulder, in order that the collar may incline rather downward than upward, in which latter case the collar will press on the horse's gullet or wind-pipe, and he may be choked, as sometimes occurs.

"But, it is to be observed that the point of draft is influenced by other considerations, viz: While it is true that a horse will *start* the greater load with point of draft near his heels, yet this is not the best for a horse whose load is light and his gait fast, as in a trotting wagon. A horse with a hard mouth will pull the wagon by his bit and bridle; hence such vehicles have the shafts crooked up, the front wheels comparatively high, and the point of draft well up.

"It is found more congenial to the horse who travels quickly, and of course, with lighter load, to have his point of draft above his heels sufficient to allow him to lean against his collar, while he throws his body forward as he steps. Another consideration is the desire to get the horse near to his work, and in cities to bring the horse as near to the car as possible. We have found, as in our Broadway omnibuses, the drivers preferred to shorten their traces and bring the horses close to the whiffle tree bar, so that the horses' heels were under the front carriage.

"The result of close observation of this subject for a lifetime makes us satisfied with the present method on cars, of having the drawhead 24 to 26 inches above grade, which is now, and has long been our rule when unobstructed."

To this I replied:

"I concede all you say about starting. My article on 'Horse Power' gave tests showing this strain to be 4 to 7 times greater than the force required to maintain motion. In an article on 'Paving' I advocate the use of selected cobble-stone. *This* gives the horse a firm foothold. Now what is the use of making him *lift* a portion of his load of car and passengers to give him a *firmer* foothold?

"As explained in my paper, which you have done me the honor to read, the requirements for a vehicle running upon a smooth iron way are quite at variance from a wagon or other vehicle traveling upon earth or pavement. For the latter a *lifting* pull is essential (as in the case of your log and stone boat). Regarding the horse's neck. With a tug of our length and height of drawbar, i. e. 25½ inches, the lifting strain is so great that the collar is pulled *down* on the top of his neck; and the fact that most of our horses having sores from the collar have them *on top of the neck*, indicates that it is due to this cause.

"Now, as to your own *practice!* You will concede that the heaviest loads are carried upon 'open cars'; yet on our open cars, as built by you, the height of drawbar is 30 *inches!*

"Observation alone will convince an experienced eye that the horses propel the open car with greater ease!"

"In Baltimore, with heavy grades, the horses are attached nearly 30 inches above grade, and the comparative ease with which they pull was so pronounced that it at once attracted the attention of Mr. Goodrich, general manager of the St. Paul and Minneapolis street railways. He spoke to me about it. I said there was an advantage in pulling upwards; that it tended to hold the horse down; that frequently when a horse had been unable to pull a loaded wagon, I had seen him succeed with the added weight of a man upon his back, etc.

"Careful consideration convinced me of the difference between the wagon and the car.

"The added *weight of the man* would be equally advantageous in either event, for the horse pulls chiefly by throwing his weight upon the collar. In a *hard* pull, the heavier the strain upon the horse, the lighter is the burden upon his front legs, because in pressing against his collar the latter supports the front portion of his body, and the weight is transferred to the hind legs, which are consequently more firmly pressed upon the ground.

"I submit the foregoing with diffidence, for I appreciate the extent and profundity of your knowledge, gathered during so many years' experience; but I must say that 3c *inches seems the best height of drawbar!*"

To the above Mr. Stephenson replied:

"Yours of the 4th inst. is at hand, regarding horse car draw head. The importance of the subject, together with my desire that you should stand right, before the public, induces this reply to your rejoinder:

"1st. A lifted load, while securing footing for the horse, also diminishes his service by the lesser journal friction and the greater ease with which the wheels surmount the bad joints and unclean surface of the rails.

"2nd. Horses keep in better condition when in work with 'high points of draft in open cars.' Our knowledge is adverse to this: *i. e.*, we understand that during the open car season, the horses become so worked out that they take till the next spring to recuperate.

"The high draft of open cars is an accident in their construction, and not because it is beneficial.

"3rd. Baltimore cars, as we understand, are not more successfully operated by a 'high draft.' The street railways of Baltimore are less profitable than in any other of our large cities in the 'temperate zone,' and there is less average efficiency in their horse power, and their cars average smaller per horse.

"Galled necks of horses is not the result of the point of draft on our cars. Poles will do this. The weight of the collar and traces, and chafing of harness, are common causes; for in the trotting wagon, with the traces horizontal, the necks of horses chafe, and the 'Dutch collar' is substituted to relieve the horse's neck.

"Spring drawheads are of vital importance in operating horse cars, and are a great relief in starting, as also at each step of the horse. A pair of horses, of a ton or more weight, put in motion, will give an impulse in starting the car, though the muscular energy of the animal should be for the moment passive; but when the two co-operate, the car is started with less strain to the animal, and furthermore, a spirited horse, finding his load coming, takes courage to continue his effort, which he would not do if the load was unyielding. Therefore the elevated drawhead is to be deprecated, because it prevents the use of a spring drawhead.

### "VARIOUS NOTIONS.

"To humor our customers, we have made between 50 and 60 different styles of drawheads, of which we now have patterns. Which is

### BEST

"We have solved by deductions from scientific study and practical experience of 55 years, and, when left unembarrassed, we give to our customers this 'BEST:'

"No one can be more interested than ourselves in having the BEST, as that is our motto.

"We are careful students of advanced science, and the developments of experience, in both of which we have aggregated as no other has had the opportunity, and our interest is manifest by this correspondence."

Considering this letter in detail:

"1st. Every 15.6 pounds *lifted* by the horse suffices to keep 2000 lbs. in motion!" As to bad joints; I went out on our track at random upon the receipt of this letter, and examined forty points where our cars stop. In Chicago, to make better time and save horse flesh, the street cars stop only at street intersections, or in the middle of blocks over 500 feet in length. The stopping place in the latter case is marked by a sign "Cars Stop Here."

I found if the car was stopped, as it should be, with the rear platform opposite the cross-walk in the street, that

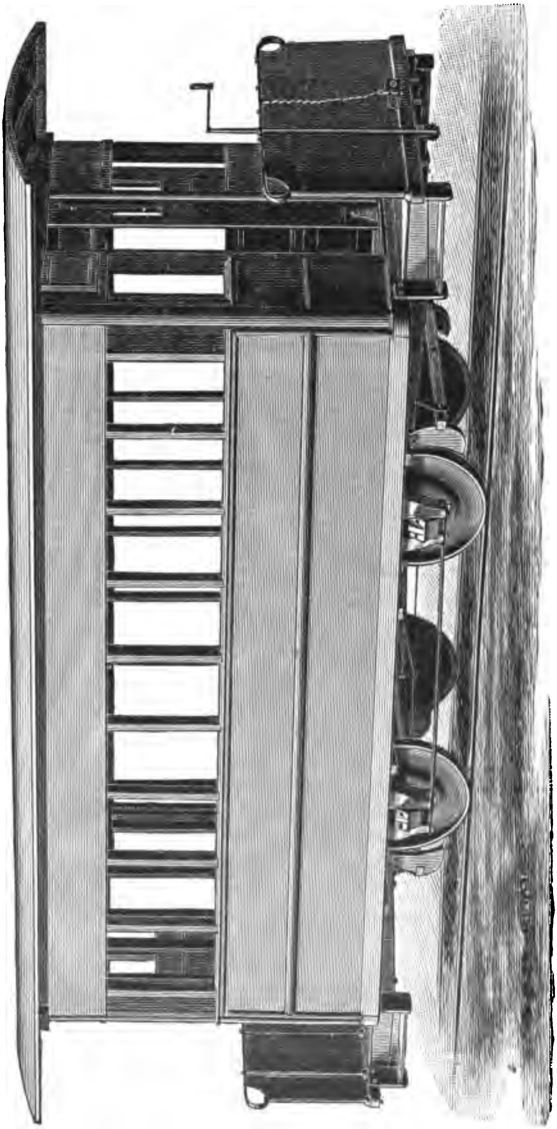


FIG. 44.

*thirty-six* out of the forty stops would occur *not* at a joint. 90% of these stops, therefore, derive no benefit from a low drawbar.

2nd. I never stated that "horses keep in better condition when in work with high points of draft on open cars." Quite the reverse is true. This is due, however, not to the high drawbar, but to the fact that the loads are greater on the open car, and the latter is used in *hot weather!* It is from heavier work and the heat that horses require a winter to recover. I am sorry to know that the height of drawbar upon the car designed to carry the heaviest loads, in the most unfavorable weather, has been the result of an accident in Mr. Stephenson's construction; although in my opinion this has been a fortunate accident, and resulted in benefit to the horse railways.

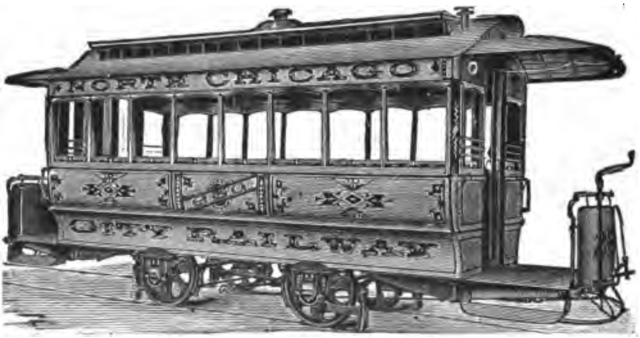


FIG. 45.

The unprofitable character of the Baltimore street railways is due, not to the high drawbar, but to the steep grades, and well nigh unlimited taxation. Their condition would be worse with the *low* drawbar.

Mr. Charles Frick, of the North Baltimore Passenger Railway Company, wrote to me:

"I have often noticed in other cities how low the horses are attached to the cars, and have wondered why they were not elevated, as with us. We find our arrangement works very satisfactorily, but as to saving in horse flesh, I can say very little, as we have used the present arrangement as far back as I can remember."

Galled necks. We use no *poles* winter or summer, so this will not apply to our horses.

*Springs* are of vital importance, but it is immaterial whether they are put *in the drawhead*, or in the *tugs*. The horse derives the same advantage in either case, with an equal compression of spring.

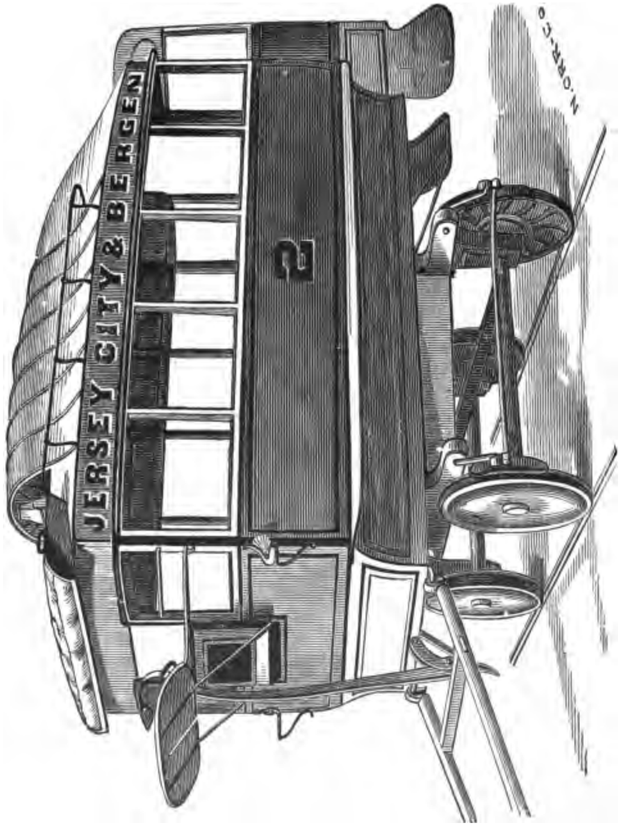


FIG. 46.

I therefore see no reason to change my opinion that 30 inches is a better height than 25 or 26 at which to attach the animal to the car.

Should any difficulty be experienced from the collar pulling upwards, a belly-band can be used. If this is buckled tight enough, it will lower the line of draught and make it more nearly horizontal.

An objection exists to the use of belly-bands without a back band, during the prevalence of flies. When the car stops, if the driver allows it to approach the horse, the tugs are slacked, the belly-band lowered, and the horse in stamping is liable to catch his hoof in the belly-band, resulting in straining and throwing him down.

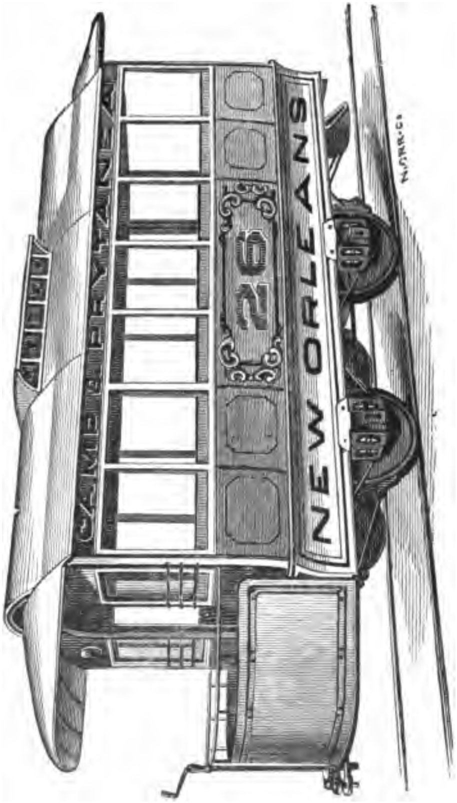


FIG. 47.

The following letter from Mr. Wm. White, the well known president of the Dry Dock, East Broadway & Battery R. R. Co. will be read with interest.

Mr. White's great experience and close observation render his opinion most valuable regarding all street railway matters; and that he approves of my views regarding the "height of draw bar" is gratifying.

Dry Dock, East Broadway & Battery R. R. Co.
No. 605 Grand St., New York, Feb. 23, 1887.

Augustine W. Wright, Esq:

*Dear Sir*—I have read your article in the February number of The Street Railway Gazette on "Height of drawbar" with much interest. Pillsbury's "Best" makes superlative bread. Stephenson's "Best" hardly requires eulogy; at all events no other than it merits.

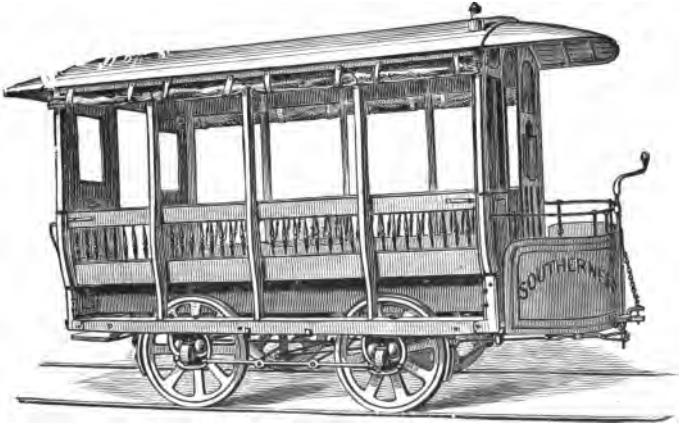


Fig. 48.

Theoretical operation of street railways is not of so obvious advantage as the practical application of observed facts to the needs growing out therefrom. It *may* be that a drawbar, on the line of the car bottom, *needs* a spring to cure its defects or modify them, so far as a spring may so do. The draft from such a line is certainly defective. On a slight up grade I have seen the front of a car lifted by the team from the rails.

A *better*, if not *the best*, line of draft is obtained from a line from the car body floor at the front door to the horses' shoulders, bringing it very nearly to your views, and would be universally adopted if the bracing of the bar to the front

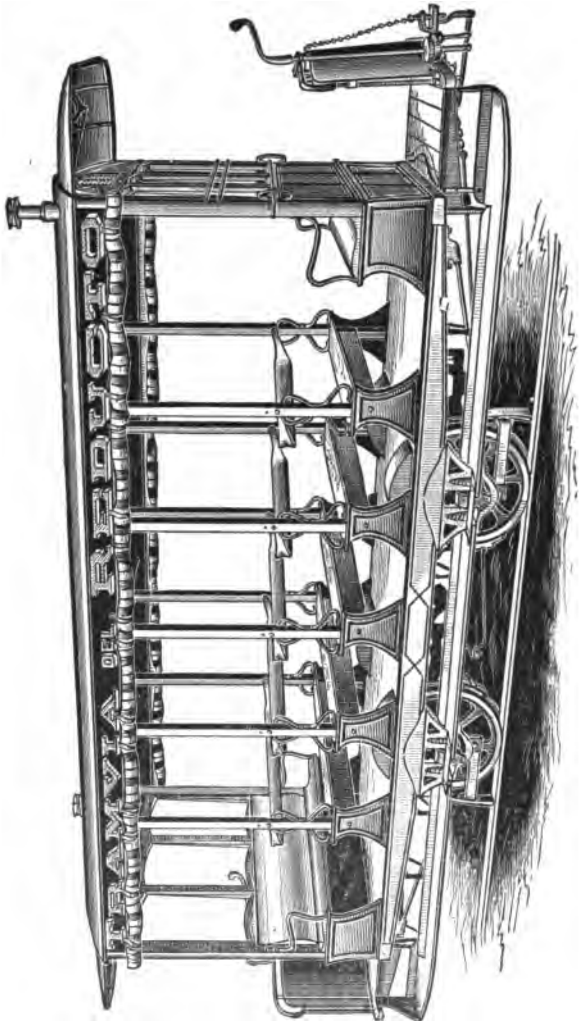


FIG. 49.

platform were not so much in the way. After many years' use, I think the elevated drawbar without a spring preferable to the "Best" at the floor with a spring.

We have about as severe grades as are anywhere surmounted by cars with horses, to-wit: 24 ft. 7 in. in 2200 ft. =1 ft. in 90 feet; 37 ft. 1 in. in 1494 ft.=1 ft. in 40 feet; 31 ft. 9 in. in 2239 ft.=1 ft. in 70 feet. Our one-horse bars are 28 inches from rails. Our two-horse bars are 30 inches from rails, when the elevated bars are used. On one line only we use the bar from bottom of platform 22 inches high. On open cars, 24 inches and 26 inches; length of traces about as in your article.

We only operate 15 open cars in summer. While these each seat 40 persons, I can not admit that the horses doing this work fare worse than those on box cars for the same period. And looking over our horse account I find we average, for past seven years, 1,067 horses; and the renewal of the same to average 18.87 per cent. per annum. This I think will compare favorably with any similar table of work from draw-bar at floor level of cars.

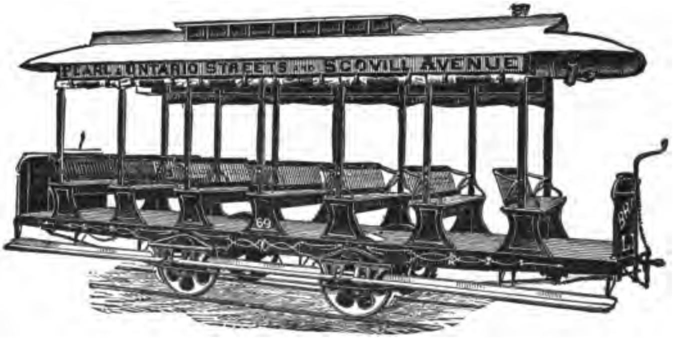

PEARL, ONTARIO STREETS AND SCOVILL AVENUE
69

FIG. 50.

I notice, of late, Stephenson places his on top of the bumper, which accounts for the three inch rise.

Yours respectfully, W. WHITE.

### RUNNING GEAR.

This is also an important matter, and worthy of careful consideration. A poor gear and bad springs add to the burden upon the horses propelling the car, to the expense of maintenance and to the discomfort of passengers.

Each superintendent has decided for himself which of the gears now prominent in the market he prefers, and any argument upon the subject by me would prove superfluous. The North Chicago City Railway Company use the "Super Gear" of John Stephenson, exclusively, as do also many other companies. The Baltimore, The Randall, The Beamis, The Higley, etc., each have extensive patronage and give satisfaction to a greater or less number of street railway

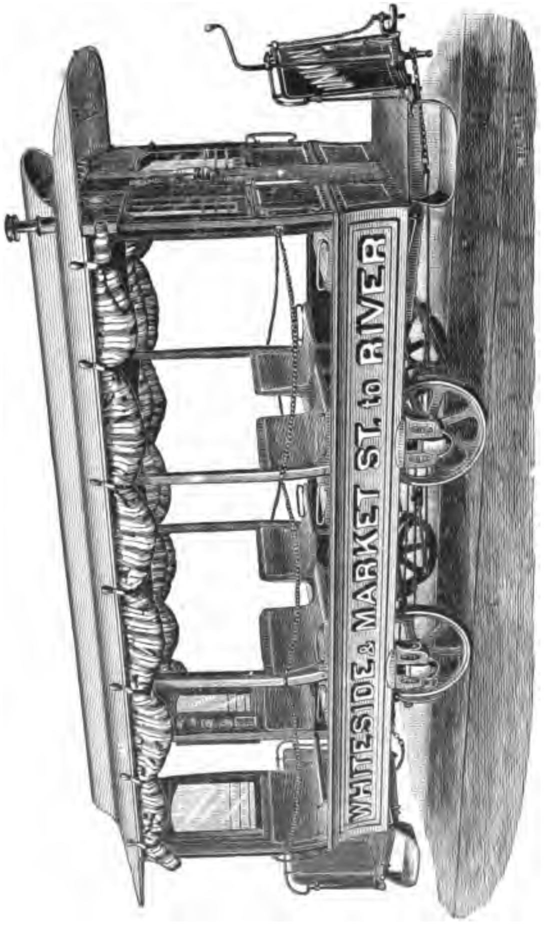

WHITESIDE & MARKET ST. to RIVER

Fig. 51.

companies, as evinced in the numerous letters of recommendation each has on file. As my experience has been limited, my opinion would be theoretical instead of practical, and I shall, therefore, simply recommend each company to investigate this subject for itself.

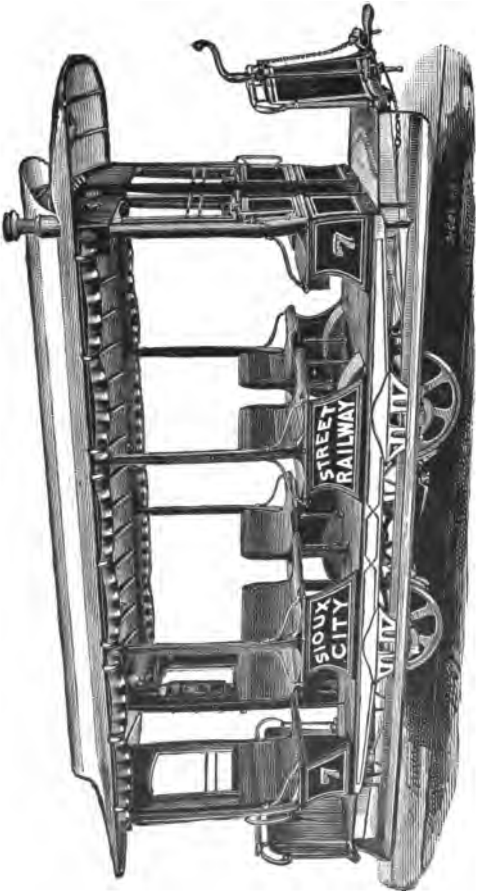


FIG. 52.

TYPES OF AMERICAN CARS.

I now propose to illustrate some of the types of American cars in the order in which the manufacturers responded to my request for information.

Fig. 44 shows a car built by John Stephenson in 1845. It was then first class, and is introduced to show the advance in construction from that date to the present, as evinced in Fig. 45, which shows North Chicago City Ry. car No. 250. This car was exhibited at the exposition of railway appliances in Chicago, and is in regular service upon the North Chicago City Railway.

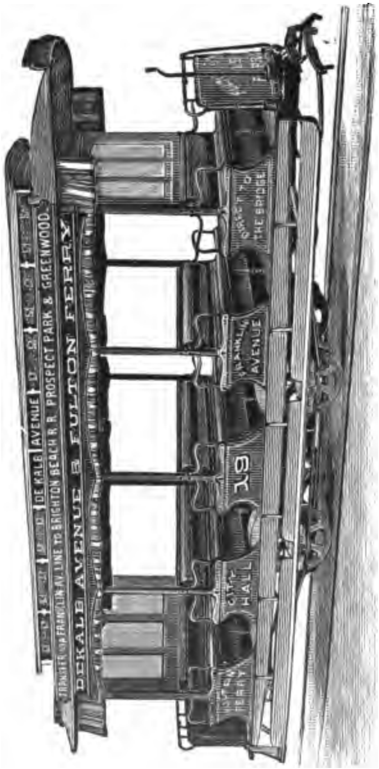

DE KALB AVENUE
TRANSFER via FRANKLIN AV. LINE to BRIGHTON BEACH R.R. PROSPECT PARK & GREENWOOD
DEKALB AVENUE & FULTON FERRY
DIRECT TO THE BRIDGE
FRANKLIN AVENUE
CITY HALL
FULTON FERRY

FIG. 53.

Fig. 46 shows a car built in 1853, for the Jersey City & Bergen Ry. Co. It was operated with one horse and turned upon its truck, thus doing away with turn-table or switch at either terminus. The driver was elevated, as upon an omnibus.

Fig. 47 shows a car built in 1860, for New Orleans, with an enclosed front platform, this end always being the front.

Fig. 48 shows a small open car built in 1874 with enclosed front platform, and passengers seated to face each other, on the sides, as in box cars.

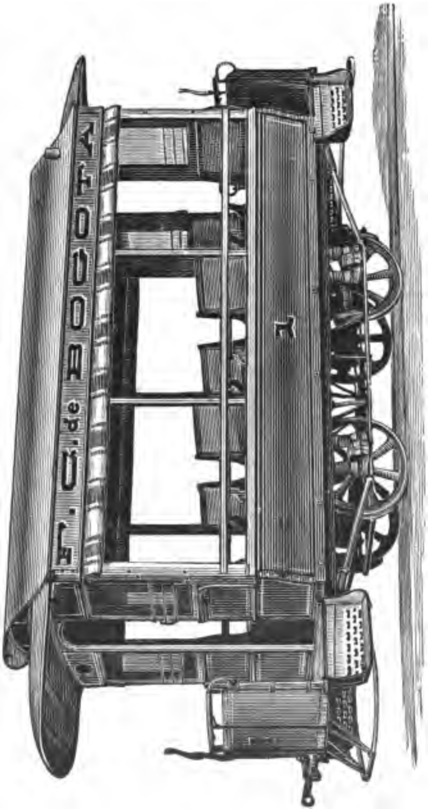


FIG. 54.

Fig. 49 shows an open car built in 1876, with reversible seats, and sash at each end, life guards before the wheels, trussed body, etc.

Fig. 50 shows an open car with reversible stick back seats (35 passengers), ventilators in roof, etc., built in 1881.

Fig. 51 shows an open car built in 1882, containing a central passage way, the passengers entering and leaving the car via the platforms. It has sashes at either end.

Fig. 52 shows a car built in 1884, which also has side steps, so that passengers can enter or leave the car at either side or either end.

In answer to my question "What do you claim as peculiar excellences in your car?" Mr. Stephenson replied:

"1st, elegence, including ornamentation.
"2nd, lightness in weight and movements.
"3rd, strength and durability.
"4th, comfort for passengers.
"5th, sash windows of metal.
"~~6th, telephone~~ for passengers.
"7th, ventilation at ceiling.
"8th, ease for horses.
"9th, car axle box with oiling pad.
"10th, drawhead with spring and safe hook.
"11th, brake, central lever.
"12th, safety, life guards and horse guards.
"13th, car running gear, super spring system."

The foregoing claims were made for the car exhibited at the World's Industrial and Cotton Centennial Exposition at New Orleans.

Mr. Stephenson received his first order from the North Chicago City Ry. in June, 1859, for four (4) one-horse cars. He has made for that company 245 cars, of which number eighty (80) were open cars.

The life guard shown in Fig. 49 is in use upon more that 600 cars, and is a valuable idea.

The horse guard has saved the life of many a horse. Without it, when one horse fell, the car ran up onto his rump. The projecting end of the brake rod, frequently tore an ugly hole as he struggled and tried to get up. From this injury I never knew a horse recover, for mortification ensued, and death came to end his sufferings. The horse guard also affords a hold to a human being who may have fallen in front of the moving car.

From the experience gained during my street railway service, I have no hesitation in affirming that the Stephenson cars are thoroughly and honestly constructed in every detail, and very durable.

Messrs. J. G. Brill & Co., of Philadelphia, favor me with the following figures of open cars. They are extensive manufacturers of steam and tramway cars of every description.

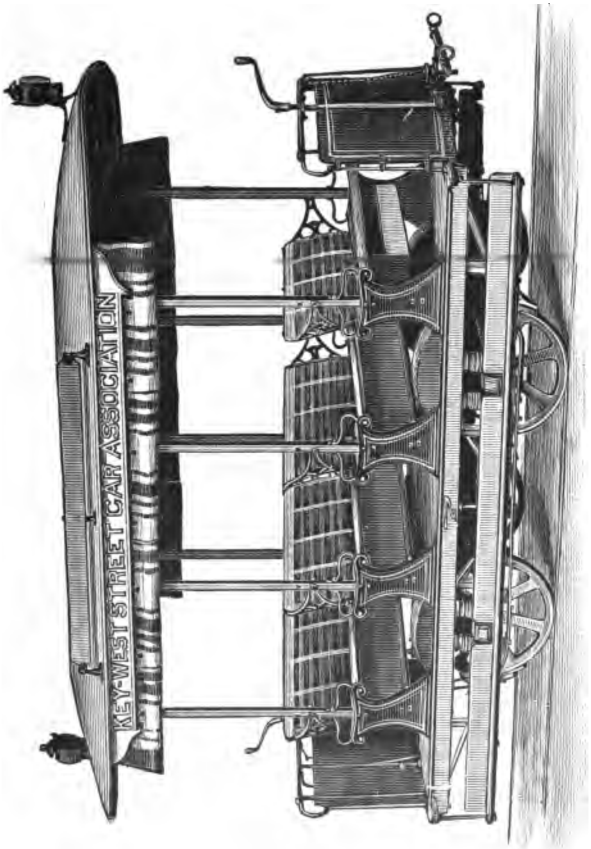


FIG. 55.

Figure 53 shows an open car, seating fifty persons. The seats are arranged *vis-a-vis*, with sash, and at each end there are curtains for the sides arranged in sections and reaching to the sills. The roof is of the class known as "monitor," with movable ventilators. The route is lettered upon the sides and ends. Ceilings are of veneer, decorated. The car is finished throughout with bronze trimmings, and has all of the maker's latest improvements.

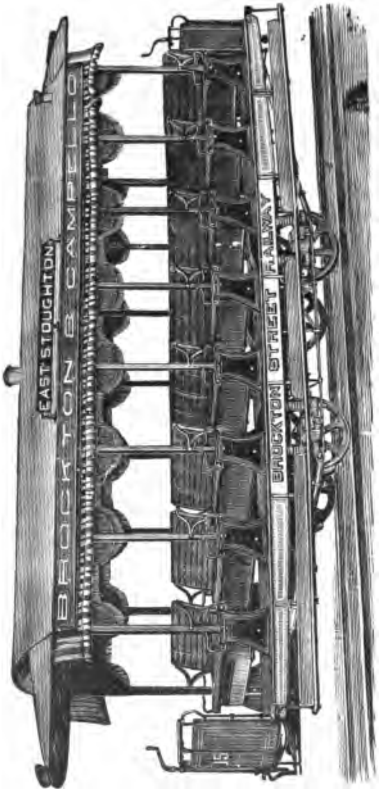


FIG. 56.

The length of car, in all, is 25 ft. 4 inches; width over seats 7 ft. 6 inches; weight, 4,700 lbs.

Fig. 54 shows a one-horse open car, having a length of body of 13 feet 6 inches, width 7 feet 6 inches. Seats are arranged *vis-a-vis*, and accommodate twenty-four persons.

An aisle runs through the center, from platform to platform, with enclosed ends, sash and doors as in an ordinary close car. Sides are paneled to the waist-rail. The side curtains draw up on rollers.

The car has patent "equalizing gear," patented brake-shoes, patent brake, corner irons, braces, and stays, and horse guards. Trimmings are of bronze. Bell pulls, within easy reach of the passengers, are upon the sides. This car can be operated with two fare boxes, or one movable fare box.

The same pattern of car is furnished with enclosed front platform and step, or open platform in the rear, with stationary seats facing to the front. Cars of the same pattern are built for operation with two horses, seating thirty-two persons. In this event the length of car body is 18 feet.

Fig. 55 is a one-horse open car with a seating capacity for twenty persons. It is arranged with patent panels, foot rests, rounded levers for the backs of the seats, which are reversible, and driver boxes. It has curtains, sides and ends, and headlights on the roof. Weight 2750 pounds.

Fig. 56 is an open car, with open ends, having a total length over platforms of 24 feet, and a width across seats of 7 feet 3 inches. The backs are high and reversible and the seats wide, with rounded seat back levers, arranged so as to prevent accidents in turning them over. Gum cushions are provided on the edge of the backs to prevent their being bruised or broken. There are grab-handles on the seat ends. They are fitted with a newly patented metal panel. In the ordinary cars these panels are made of 3/8 inch poplar, bent to shape, concave and convex, and fastened to a frame work, which is boxed into the post by gaining out from 1/2 to 3/4 of an inch, and fastened also to the sills. This gaining of the post necessarily weakens it, to overcome which the posts are made larger, thereby increasing the width of the car, and providing a place for the collection of water, which rots the wood. They are the most vulnerable part of the car, being easily broken, and checking. They are hard to repair without good shop facilities and are expensive. The metal panel overcomes these objections, never wearing out. It also lightens the car. Foot rests are provided on either side of the seat, and driver boxes under the front end of rear seats.

The signs are patented, and are made so that when hey are pushed up they will reverse, and can be made to show two, three, or four sides.

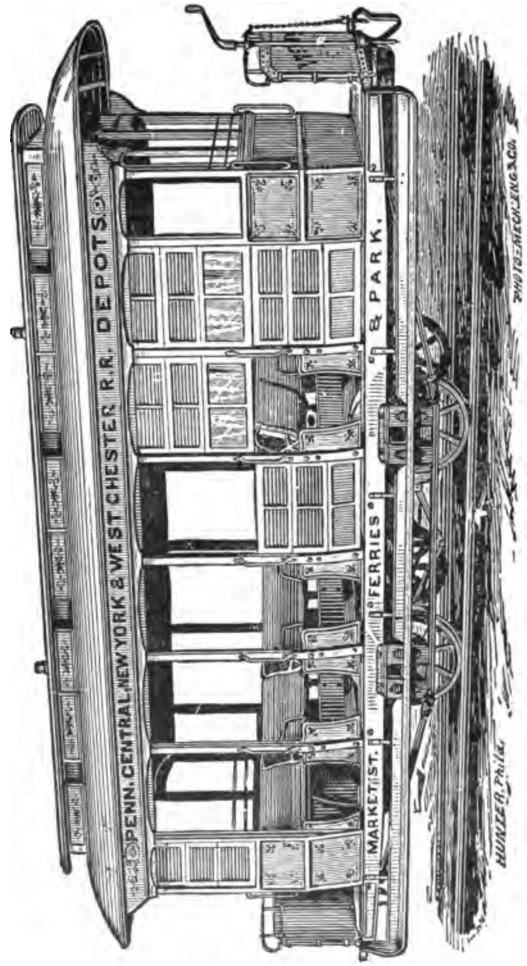

PENN. CENTRAL, NEW YORK & WEST CHESTER R.R. DEPOTS
MARKET ST. FERRIES & PARK.
PHOTO-MECH.ENG.CO.
HUNTER, Phila.

FIG. 57.

The curtains on the sides and ends reach to the sills, and there are lambrequins on the insides. Two end lamps and one center lamp are provided. Rubber balls are fitted to the lower end of brake shaft to prevent injury to horses. They have a seating capacity for forty persons, weight 4400 lbs. These cars are also made to seat 35, 30, 25, 20, and 15 persons each.

Fig. 57 is designed for use in tropical countries, and is intended for operation during the whole year. It has the "monitor roof," with ventilators in sides and ends, extending the entire length of the car body. It has enclosed ends with blinds, and blinds also on sides arranged so that when not in use they can be slid up into the roof. The seats are reversible, and the car has a seating capacity for 35 persons. Extreme length 24 feet; width at seat 7 feet 6 inches; weight 4500 lbs.

Other well-known manufacturers of cars are the Pullman Co., of Chicago, Brownell & Wight Co., of St. Louis, and the Laclede Car Co., of St. Louis.

## CHAPTER V.

### BUILDINGS FOR STREET RAILWAYS.

This subject will be considered under the following heads: Stables and Car houses.

### STABLES.

The horse railroad companies in the United States employ nearly a hundred thousand horses and mules. No other lines of business aggregate such large numbers under the supervision of so few men. Anything affecting the health of these horses is a matter of prime importance to the various owners, and the construction of the stables in which the car horse passes so many hours should receive the careful consideration its importance, measured in dollars, demands. Permit me to quote from a report that I made to the American Street-Railway Association on "Buildings":

"We appeal to you in behalf of the horse, to give him suitable stable quarters; but this we urge upon the score of economy, rather than humanity. No other line of business employs as many horses in the cities and towns of this country, under one management, as the one we represent, namely, horse railroads. About 30% (to 40%) of our operating expenses is expended in the horse department, amounting in the aggregate to a vast sum of money. Anything that will reduce this expenditure, by prolonging the life of the horse, which is now about four years, more or less, is worthy of investigation. Badly constructed stables are responsible for many, very many, of the diseases among horses. The paramount importance of abundant sunlight, perfect sewerage and good ventilation is now, fortunately, recognized almost universally in building human habitations, but how often ignored in providing quarters for the horse, the number sick and unfit for duty, most eloquently testifies. John Stewart wrote, 'Stables have been in use for several hundred years. It might be expected that the experience of so many generations would have made them perfect. They are better than they were some years since. * * * A damp stable produces more evil than a damp house. * * *

Since 1788, when James Clarke's work was published, protesting against close stables, there has been a constant outcry against hot, foul stables. Every veterinary writer, who has had to treat of diseases, has blamed the hot stables for producing at least one half of them.'

"Jennings wrote: 'The most desirable thing in a stable is ventilation. A horse requires air equally with his master, and as the latter requires a chimney to his sleeping apartment, so does the former.'

"Henry W. Herbert, better known as Frank Forester, wrote: 'In a climate so uncertain, changeful, and in which the extremes of heat and cold lie so far apart as in this country, the question of stabling is one of paramount importance. The stable, to be of real utility, must be perfectly cool, airy and pervious to the atmosphere in summer; perfectly close, warm, and free from all drafts of external air, except in so far as shall be needed for ventilation, in winter; perfectly ventilated, so as to be pure and free from ill odors, ammoniacal vapors and the like, arising from the urine and excrement of the animal; at all times perfectly dry under foot and well drained, since nothing is more injurious to the horse than to stand up to his heels in wet litter. * * * Lastly, it should be perfectly well lighted, as well as thoroughly aired.'

"Stonehenge wrote: 'The horse, like all the higher animals, requires a constant supply of pure air to renovate his blood; and yet it must not be admitted in a strong draft, blowing directly upon him, or it will chill the surface and give him cold. * * * By common consent, it is allowed that no stable divided into stalls should give to each horse less than 800 or 1000 cubic feet.'

"Youatt wrote: 'It is not generally known, as it should be, that the return to a hot stable is quite as dangerous, as the change from a heated atmosphere to a cold and biting air. It is the sudden change of temperature, whether from heat to cold, or from cold to heat, that does the mischief, and yearly destroys a multitude of horses.'

"One more quotation, from John Osgood, who, in speaking of city stables, said: 'Now, in the name of humanity and ordinary commercial thrift and sagacity, let this be stopped! There is no reason why stables should be horse-hells!! No reason why they should vie with the 'Black Hole' in their inevitable cruelty, and gloom, and destruction. These, and city stables generally (with some exceptions) are a disgrace and a shame to a civilized community. So long as they continue as they now are, horses must die. There are no remedies for the sudden and violent diseases which attend such poisonous air, and water, and food. The remedy lies in providing ample and well ventilated stables—stables well lighted, with stalls of ample dimensions, with escape pipes for the ammoniacal effluvia which arises from so many animals, and their excretions, with more room for evaporations; and then the chances would no longer be against every horse who passes through these doors, as they were against those ghostly ones who passed through Dante's gate, and as they went in, read above their heads,

'Who passes here, goes into everlasting hell.'

Improve the stables then, and prevent disease. * * * Do not insult a respectable animal, who has come from the country to do his share of the work of the world, and has brought with him the memory of the sweet hills and skies at least, by immuring him in one of those cramped, rickety, rotten, stinking, slovenly, damp dungeons, where a dumb beast would loose his self respect and his courage, beneath an oppressive weight of miasma and hideous, gloomy, nasty confusion. Stop this, or pray that horses may die, ere the evil days come.'

"We have quoted thus extensively, to emphasize and impress upon you, if need be, as among the first requirements for your stables, good ventilation, drainage, and abundant light, matters of prime importance in any stable, but much more so in your own, where the horse spends frequently twenty of the twenty-four hours, whereas in other lines of business, he often spends not more than eight hours of the twenty-four in the stable."

### A NORTH CHICAGO CITY RAILWAY STABLE.

I will now describe a stable built by me for the North Chicago Railway, in which I have attempted to provide the essentials of light, ventilation, drainage, etc. It fronts south 125 feet upon Belden avenue, east 238 feet upon Jay street, both streets being 66 feet in width; along the west side there is a public alley, 16 feet wide, and 50 feet additional vacant ground. On the north there are 12 feet vacant; property of the company. Light and ventilation are therefore obtained from all four sides. (See figure 58.)

The horses face north and south, and in the rear of each row, an alley 10 feet wide extends entirely across the stable, with a sliding sash door at each end 7′x10′. Another alley 9′ 6″ wide, extends the entire length of the stable at right angles to the first described alleys, with large, sliding sash doors at each end.

The stalls are 9 ft. deep, and each horse is allowed 56 inches of width. Double stalls are, in my opinion preferable, when horses will stand together quietly, but the service of horses on street railways is so comparatively brief, that many teams will not stand quietly together in double stalls and I therefore alternated a double stall, with two single stalls, thus permitting the foreman to place the horses who do not agree with each other, in single stalls.

The floor of this stable consists of 4 inches of asphalt, having scantlings embedded therein 2″x4″, placed on sixteen inch centres, to which a pine floor is spiked. The latter consists of boards surfaced one side, and put in the hot asphalt, which fills every joint and is water tight. A flooring of two inch common plank is placed on top in the stalls, to take the wear. The stalls incline two inches from their head to a gutter in the rear, which connects with a catch basin through suitable traps. These gutters are covered by cast iron plates six inches wide, fifty-six inches long, perforated to allow the urine to pass into the gutter. These covers are movable, and at least once each week they are all taken up and thoroughly cleansed by scraping and washing, in addition to which some disinfectant should be used.

Between each row of horses there is a "feed-alley" four feet wide. By this construction the horses are not brought head to head, to breathe each the other's breath, contaminated perchance by disease, which is thus spread from one to another. Food is not wasted in placing it in the manger, for it is taken directly from a feed cart in the alley in front of each animal. There is less danger of an employee being injured, or perchance crippled for life, in entering the stall to feed some vicious or frightened horse.

At each end of these feed-alleys windows are placed, containing 32 lights of glass 9″x14″, a size I adopted as a standard, and used whenever possible to avoid carrying a stock of various sizes. In these feed-alleys, beneath the floor, there are placed fresh air ducts extending clear across the stable, from outside to outside, through which fresh air is

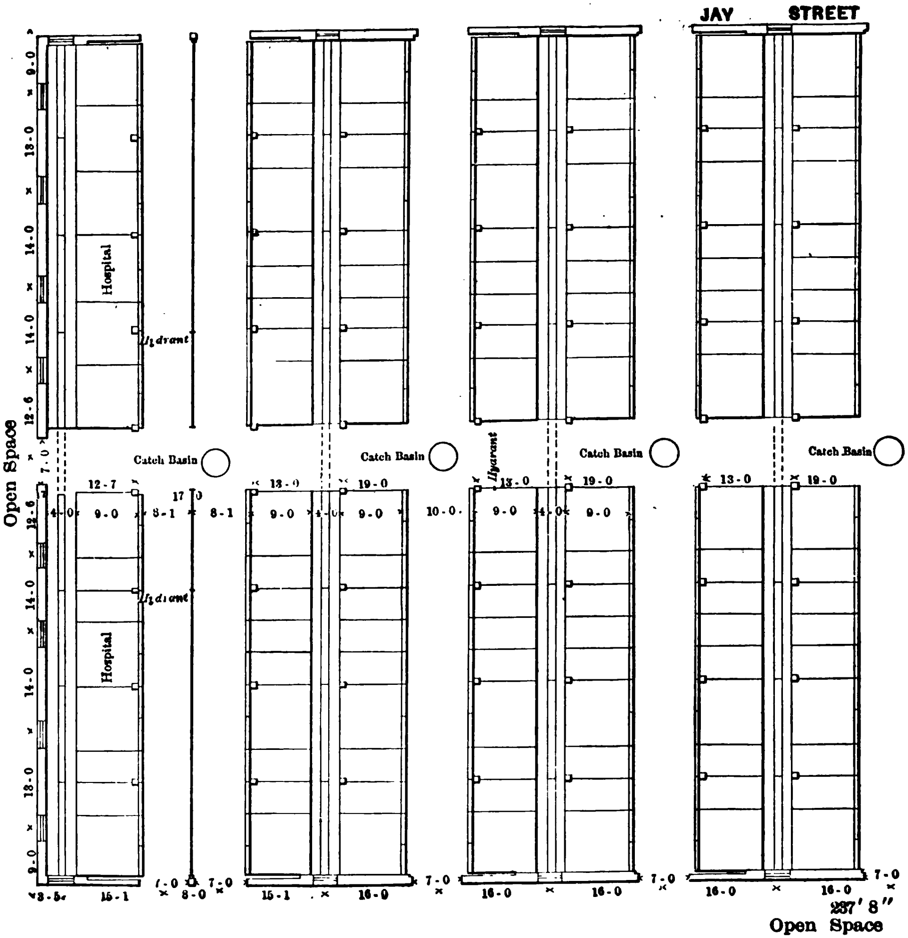
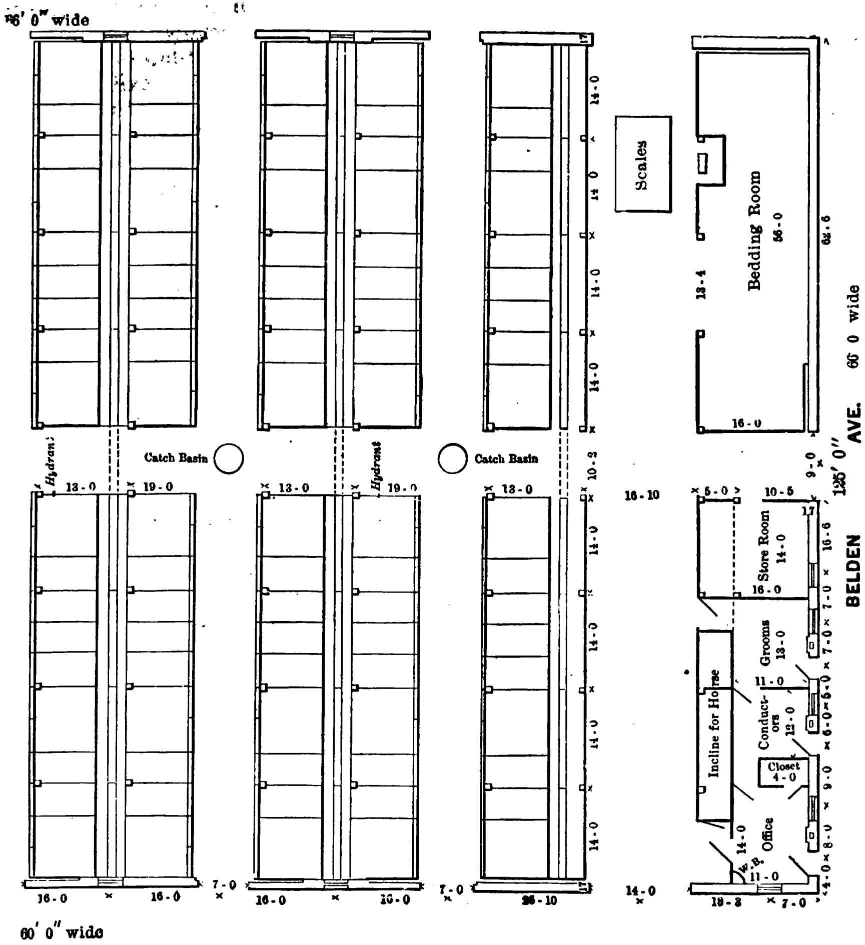


**Fig. 58.—Ground Plan of North**



**Chicago City Railway Sta.**

admitted, passing out into the stable through perforations in its cover, thus avoiding injurious drafts. Its exterior openings are protected by cast iron grates built in the brick work, preventing the entrance of vermin, especially the pestiferous rat. In this stable there are nine ventilators, one located at the intersection of each alley, for the exit of foul air. They are 6'x6' at the lower end, and taper to 4'x4' at the top, extending 8' above the roof. The four sides, above the roof, are movable, except the posts, having projecting aprons, inclining at an angle of 45°, thus deflecting the air upward, and doing away with downward currents; permitting the opening to be reduced in cold or inclement weather, ropes extending to the first floor for this purpose. I was indebted to Mr. John Stephenson for the idea of this construction. It resulted from many experiments made by him upon ventilation while a member of the New York School Board. The gas burners located under these ventilators, assist in the ventilation by heating the air, which ascends and increases the outward-bound current of impure air.

### VENTILATION.

When first called upon to design the ventilators for a stable, I turned to my engineering library, and consulted book after book, in vain, to ascertain the proper amount of fresh air to provide each horse. I asked engineers, physicians and veterinary surgeons without obtaining the information. The Civil Engineers' and Architects' Journal for 1841, page 103, states: "The Committee of the Academy of Paris to whom the question, 'what is the quantity of air necessary for the healthful respiration of the horse?' was referred by the Minister of War, reported that in a building where the air is properly renewed, and that result is effected by a skillful and efficient system of ventilation, a horse can never suffer so long as he has from 25 to 30 cubic meters of air"—883 to 1060 cubic feet. Upon a previous page I have quoted Stonehenge, who allowed from 800 to 1000 cubic feet per horse, but these statements did not solve the problem; and, desiring to have *enough* fresh air, I built ventilators as above described, allowing one such ventilator for about 40 horses. Assuming that air expands $\frac{1}{490}$ of its volume per degree Fahrenheit, and that it is winter weather, the interior of the stable being 15 degrees warmer

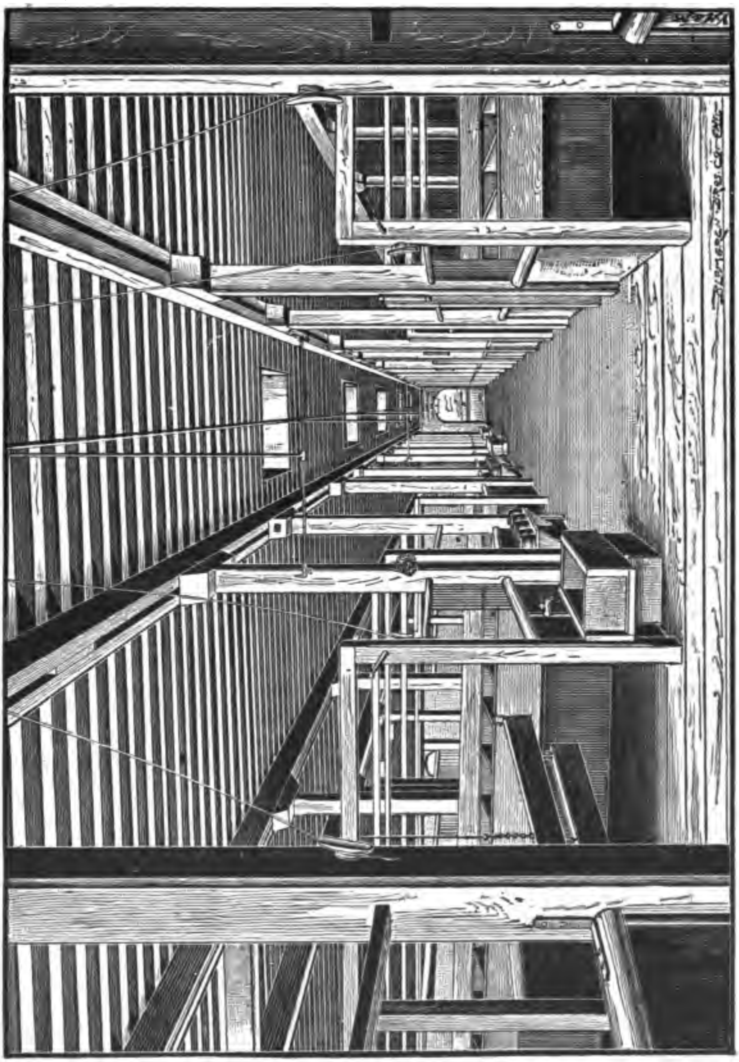


FIG. 59.—INTERIOR VIEW OF STABLE.

than the exterior air—for, in my opinion, the horse enjoys better health if the stable temperature varies only 10 to 20 degrees from the exterior air, than he does in a hot stable—the air inside the stable would lose in weight (the ventilator being 20 feet high) $\frac{20\times15}{490}=.612$ foot. That is, it would be lighter than the outside air by the weight of a column of air .612 foot high. The velocity with which the outside air column would try to get in at the base of this shaft would be governed by the same law as that of a body falling through the space of this excess of height. The formula for this velocity is $V=\sqrt{2gh}$, $g$ representing the force of gravity, here about 32, and $h$ the height or space through which the fall is made; substituting, we have $V=8\sqrt{0.612}=6.26$ cubic feet per second per square foot of ventilator. We must deduct from this amount the loss by friction of the air against the sides of our ventilator. Being a straight beveled box, with smooth sides, this loss will probably not exceed 0.3 of 6.26 cubic feet, say 1.90 cubic feet. Deducting this amount from the former, leaves 4.36 cubic feet, per second per square foot of each ventilator, passing through, and multiplying by 3600, the number of seconds in an hour, and by 16, the number of square feet in the ventilator, and dividing by 40 the number of horses supplied, $\frac{3600\times16\times4.36}{40}=6278.4$ cubic feet of air per hour for each horse, under the conditions assumed.

In summer the doors and windows are open, and as most of my stables have air and also light from four sides, through many openings, there is no trouble about ventilation at that time of year.

I stated that the location of the gas burners, under the ventilators, assisted in the ventilation. The part they perform is as follows: There are two burners, consuming each four cubic feet of gas per hour. The quantity of heat evolved by the combustion of a cubic foot of ordinary illuminating gas, is estimated at 700 heat units. The two burners would therefore evolve $2\times4\times700=5600$ heat units per hour, or 93.3 per minute. The specific heat of air is 0.238 nearly. A cubic foot of air at 45° F. weighs 552 grains. $\frac{552}{7000}=.0789$ pounds. The amount of air that would be heated 1° F. by the two burners per hour is $\frac{93.33}{.0789\times238}=$ 49.701 cubic feet, which assists in creating a current of air through the ventilator.

Gen. Morin found by experiments the amount of air necessary for the healthful respiration of the horse to be from 5637 to 6263 cubic feet per hour. The English army regulations are said to allow to each horse a space of 1605 cubic feet, 100 square feet of floor, and 2466 cubic feet of air per hour. My practice coincides very closely with the amount found necessary by Gen. Morin, although I was ignorant of his experiment. The health of the North Chicago Railway horses confirms me in the belief that the ventilation of their stables is ample. Mr. Robert Atkins, superintendent of the horse department, reported to me in February, 1885, as follows:—

"The number of horses owned by the North Chicago Cy. Ry. Co., at the present time, is 1658; average number owned during 1884, 1500. Average number unfit for duty from *all* causes, 38½; but this includes 150 new horses purchased fresh from the country to operate a new line, who suffered with distemper in being acclimated. Excluding them, the average was 32, or about 2%. Forty-five horses died during the past year—14 from accidental injuries, 10 from colic, 5 from lung fever, 4 from paralysis, and 12 from eight other diseases."

Deducting the 14 from accidents and 10 from colic, leaves 21 deaths only that might have been remotely affected by ventilation—being 1.4%. Surely this experience indicates ample ventilation, and I therefore consider the above construction as quite satisfactory.

Continuing the description of the stable in question: The first story is 16 feet high. Fig. 59 is an interior view looking down the center of the stable. Second story 7 feet at the side walls and 9 feet at the center. Each horse has 1216 cubic feet of space. The hay loft suffices to stow one year's supply of loose hay, besides containing a horse-power and hay-cutter and feed department. Fig. 60 shows the floor arrangement, and fig. 61 an elevation of this department. The latter contains a number of bins in which the feed is stored, a large room for cut hay, one day's supply at least being always on hand in the event that the cutter should break.

There are two mixing troughs, each 16 feet long, 4 feet high, 4 feet wide at their tops, and 3 feet at their bottoms, made of 3" stuff put together with white lead in joints and thoroughly water tight. A chute carries the feed after it is mixed down to the first floor, when it drops into carts and

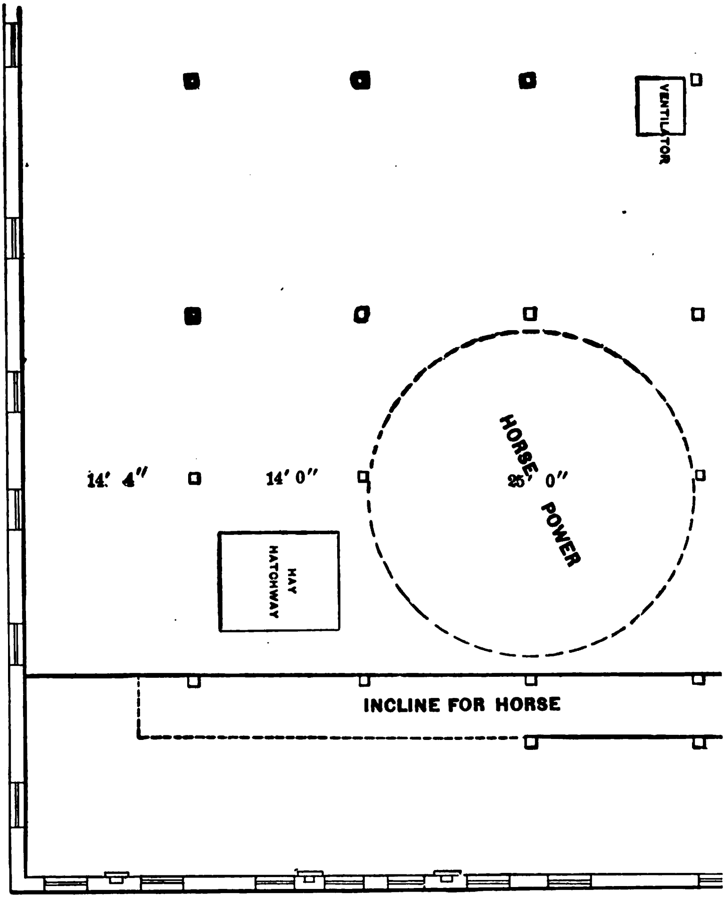
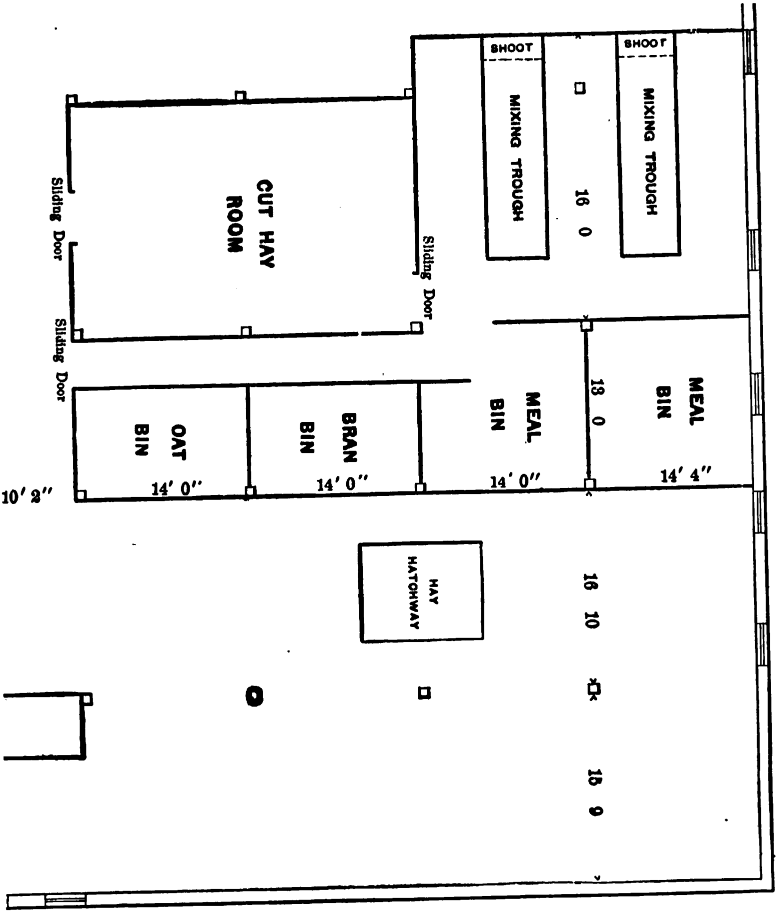


FIG. 60.—FLOOR OF



Feed Department.

is distributed; shavings are used for bedding, as they can be cheaply and abundantly obtained during the summer, but are scarce and high, during the winter, the bedding room provided is large, being 16x50 on the ground floor, extending clear to the roof, with an addition on second floor 16x70. The cost of bedding obtained in this way is one half cent per diem per horse.

A hospital should always be provided, where a sick animal can be separated from the others and be as quiet as possible. In this stable it is located at the north end, in the most quiet spot. Here the tubs are placed containing salt water foot baths, in which the horses stand and soak their feet as mentioned in a previous chapter. At this end of the stable the blacksmith shop is located, but without a forge as the horses are shod cold, no heat being permitted. The entire interior is whitewashed regularly.

Scales are provided upon which supplies are weighed. An office is provided for the foreman, and separate rooms for grooms and conductors, with suitable closets, store rooms, etc.

I think with Youatt that the stable should not be too warm in winter. Nature is a safe guide, and she provides the horse with a suitable covering. The stable temperature should, in my opinion, vary not more than 10° or 20° from the external air. Keep the stable cool and if necessary throw a blanket over the horse while hot, just in from work, during severe winter weather.

The horses passing over twenty hours per diem in the stable, the importance of thorough sanitary arrangements is thereby largely increased.

I believe that horses frequently suffer more from thirst than railway managers are disposed to admit. In this stable numerous watering tubs are provided, and every horse employed by the company is watered during the night, in addition to the day time. Some fine railway stables have been built, containing an arrangement by which each horse has before him a constant supply of fresh water. A decided difference of opininion was manifested upon this question by the members of the American Street-Railway Association.

The following are the specifications for mason work and carpenter work, together with bills of materials therefor, of stable.

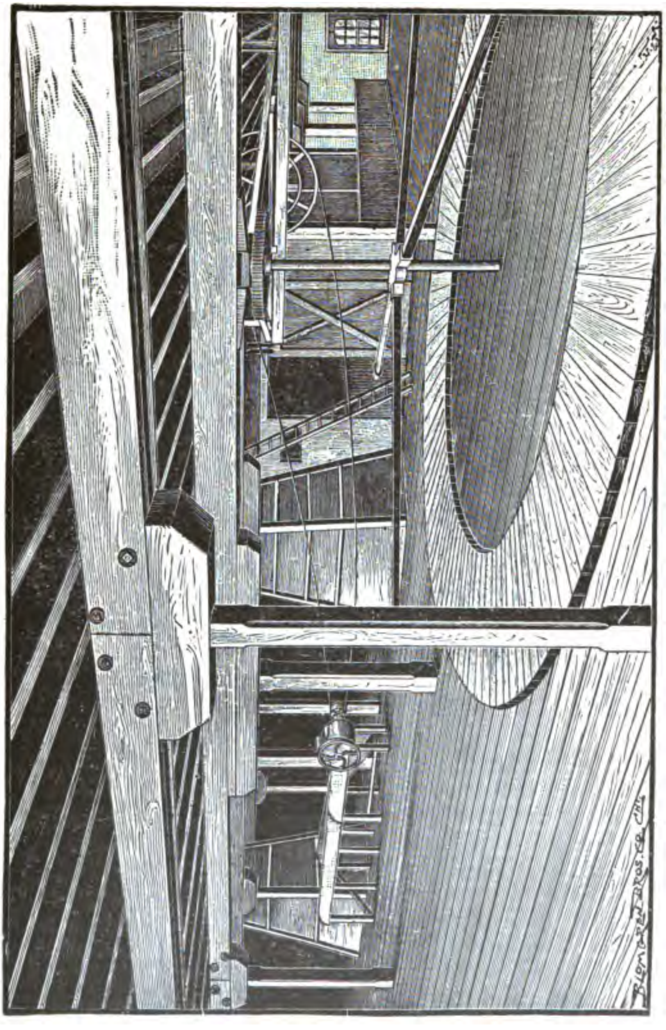

BLOMGREN BROS. CO. CHI.

FIG. 61.—ELEVATION OF FEEDING DEPARTMENT.

## SPECIFICATIONS FOR MASON WORK FOR NORTH CHICAGO CITY RAILWAY STABLE, CORNER OF JAY ST., AND BELDEN AVE.

The building will be of brick, two stories in height, 125′×238′, as shown in accompanying plans.

The contractor will be strictly held to execute such work and use such materials as are herein-after described, and he must submit in regard to the character of the materials used, and work done, to the judgment of the superintendent.

The contractor must have a competent foreman on the ground at all times during working hours to attend to the work and receive the instructions of the superintendent. Sub-contractors will not be recognized.

The contractor must take down and remove all inferior or defective work or materials upon being directed so to do by the superintendent, at any and all times, within 24 hours after receiving notice to that effect. But if the contractor shall neglect or refuse to take down and remove said imperfect materials or work, then the owner or superintendent shall have power to take down and remove the said imperfect work or material and replace the same with such as are in accordance with the plans and specifications, at the cost and charge of the contractor.

### EXCAVATION.

Excavate the ground for all foundations to the depth marked or shown in the plans. After using so much as may be required by the superintendent, the surplus, if any, shall be removed from the premises.

### STONEWORK.

The foundations under each pier shall be of dimension stone eight inches thick, in one piece 4′×4′.

The foundation under all walls shall consist of large flat-bedded rubble, well and thoroughly laid, so as to break all joints. It will be 3′ 0″ wide and 16″ high. Above this height to the top of stonework the walls will be 24″ wide at the bottom, tapering to 16″ at the top. The walls are to be built to the height marked or shown in plans or sections, and laid in cement mortar; the interior to be filled solid with spawls and mortar, leaving no interstices. The top to be perfectly level and straight.

### STONE.

The stone used to be the best quantity of limestone, flat-bedded and nearly equal thickness and subject to the inspection and rejection of the superintendent.

### MORTAR

The mortar for stone work will be composed by measure of one (1) part Utica or Louisville cement of best quality to two (2) parts of clean lake sand, and mixed in small quantity as needed. Retempering will not be permitted.

The lime mortar shall be made of clean sharp lake sand, thoroughly mixed and incorporated with fresh burned quick lime in proportion by measure of two (2) parts sand and one (1) part lime.

### BRICK.

The brick used shall be good, hard burned, straight and true, and free from lime. They will be subjected to a rigid inspection, and all soft or defective or inferior brick rejected. All bricks shall be well wetted before used and shall be laid perfectly plumb and straight, well banded and tied together in band of five (5) courses of stretchers to one (1) course of headers. The joints and all interstices shall be flushed full with mortar, leaving no voids or empty spaces in the walls. The joints on the outside and inside of all unplastered walls shall be neatly struck. Arches shall be built over all openings, inside and outside. Bed carefully and solidly all door and other frames, and underpin all sides with mortar. Cover up all work during inclement or wet weather. Do all necessary cutting and build all cornices or other projections in the best and most workmanlike manner.

### LATHING AND PLASTERING.

The office, conductors' and grooms' rooms will be lathed with sound 1⅜ inch pine laths, ⅜ inch apart, and firmly nailed to each bearing. Joints broken once in six (6) courses.

Plaster the sides of walls with two (2) coats of mortar. The first coat to be of hair mortar well floated, and the second of clean sharp lake sand and plaster of paris, troweled down perfectly smooth. Ceilings will have three (3) coats of mortar.

### CUT STONE.

Each pier shall be covered with a limestone cap, sawed top and bottom, 6″×17″×17″. Each post shall set on a sawed limestone plinth, 10″×10″×17″.

The window sills shall be sawed limestone, 5″×8″×4′—0″ Three door sills weathered 6″×20″×3′—4″.

362 lineal feet of coping will be 3″×24″, and 362 lineal feet 3″×12″, all sawed and no piece less than 4′—0″ in length.

There were 649 cubic yards of excavation, 1824 square feet of dimension stone, 56 cords of rubble, 473 thousand brick, 114 band stones, and 114 plinths, 72 window sills, 3 door sills, and 724 lineal feet of coping in the above building.

The plinths upon which the posts set are quite essential, for it is at this point that the posts first rot, if carried to the floor level. By keeping the top of these stones, and consequently the bottom of the posts two inches *above* the floor level, this rotting is prevented.

### CARPENTER WORK.

The following are:

### *Specifications for Carpenter Work.*

Stable for North Chicago City Railway Company, Jay street and Belden avenue.

### GENERAL CONDITIONS.

The contractor must give his personal attention and superintendence to the work; must furnish all transportation, labor, materials, and apparatus, scaffolding and utensils needful for performing the carpenter work in the best and most workmanlike manner, according to the drawings and specifications.

All the material to be of the best description. Should the contractor introduce any material different from the sort and quality herein described or meant to be implied, they shall be removed within twenty-four hours after notice to that effect from the superintendent, A. W. Wright.

The works are to be executed in the best, most substantial and workmanlike manner, according to the true intent and meaning of these particulars and the drawings referred to, which are intended to include everything requisite and necessary to the proper and entire finishing of the carpenter work, notwithstanding every item necessarily involved in the said work is not particularly mentioned; and all the work, when finished, to be delivered over in a perfect and undamaged state without exception. No part of the work to be underlet unless by written consent of A. W. Wright.

The contractor to be responsible for all violations of law caused by his obstruction of streets, sidewalks, etc., with his materials, and, at the completion of the work, shall remove all his rubbish and material from off the premises. The carpenter to do all necessary woodwork, cutting, etc., for other craftsmen on the building; to provide and set centers on which to turn arches.

The drawings and specifications are the property of the superintendent and must be returned to him on completion of the work. The contractor shall not make any alterations of the drawings. Should any error appear in them he shall refer to the superintendent for corrections. He must carry on his work at all times with the greatest reasonable rapidity under the direction and to the satisfaction of the superintendent.

## TIMBER.

All the material used in and throughout the building to be of the best common pine lumber, except as hereinafter specified. To be free from sap, shakes and other imperfections impairing its durability or strength. Well seasoned; sawed, square edges.

The studding in plastered partitions will be 2"x4"—16" centers. First floor joists the same buried in asphalt cement. All joists to have full and true bearing, with an inclination in the stalls of 2" towards the rear.

The carpenter shall make all boxes for the plumber for each hydrant or stop-cock, make all necessary watering and mixing troughs, sizes as shown on plans, of 3" dry pine and put together with white lead and rope centers in joints. He shall make all boxes necessary to be built in brick walls for the proper sliding bars.

Boxes to be of 1" stuff, surfaced one side. Bars 3"x6," surfaced four sides, clear pine.

## GUTTERS.

All urine gutters and air ducts to be placed in position according to plans. Urine gutters to have sides of 2"x12" common pine, with strips 1"x2" nailed on the inside, with an inclination of ten inches in the length of gutter, to catch basin, to which proper connections shall be made. Iron covers over same to be let into the floor at least ¼ inch more than the thickness of the iron, and to have a true bearing throughout their length. Air ducts to have covers of 2" pine, perforated with holes 1½" diameter, and five inches apart, proper supports to be framed to carry these covers.

### FIRST STORY FLOORS.

The entire first story will be covered with common pine boards, surfaced one side, and bedded in hot asphalt and well nailed to joists. Upon this, in all alleys, there will be a wearing floor of common pine, 3" thick. Posts carrying second story will be 10x10, surfaced four sides, and corners chamfered, of good and sound pine lumber, sawed square, all to have good and true bearings on plinths, and set plumb and true.

Corbels 10"x12"x4'—0", dressed four sides and cut to pattern, and well spiked to posts.

Cordties dressed one side to 1⅞", and depth corresponding to girder. Girders 4"x14"—6"x14"—6"x16," as shown on drawings. To be sized of equal hight over corbels, to true and level bearing. To be well bolted, as shown on plans, and nailed to corbels. Spans over 16 feet to be packed and bolted.

### SECOND STORY.

Joists to be 2"x12," laid 16" centers, all to be of equal depth on bearings and bridged each 8'—0' of length, with 1½"x3", cut to fit, and well nailed with 10d nails. Frame all necessary headers and trimmers around chimneys and ventilators, and wherever required.

Floor to be of dry, common fencing, dressed and matched, all loose or unsound knots to be cut out and floor laid close and well nailed with 8d nails.

Posts to be 6"x6" or 10"x10" as shown on plans. Cut in lengths to form roof pitch of ½" in 12"; corners chamfered and set plumb and true; corbels for same to be 10"x12", cut to pattern and securely nailed to posts.

Girders 3"x12"—6"x12"—6"x16", according to plan. Sized over corbels to level and uniform bearing.

Roof joists to be 2"x12", laid 16" centers, sized on bearings, well bridged, each 8'—0", lineal feet, with 1½"x3" stuff, securely nailed with 8d nails. To be covered with common boards, dressed one side to ⅞", all loose or unsound knots, shakes, or imperfections to be cut out, well nailed at each joist with 10d nails. Furnish and cut all wall plates 2"x4" for proper nailing of roof felt to brick walls.

### VENTILATORS.

There will be —— ventilators. For construction see detailed drawings.

### PARTITIONS.

Unless otherwise specified, partitions will be of 2″ pine surfaced two sides, and joists covered with battens on one side, 2½″ wide. Girts for same, 2″x6″, dressed four sides.

Stall partitions will be of 2″ common pine, surfaced two sides, to 1¾ and 3′—6″ high, stood perpendicular, with lower end let into floor one inch, and upper end held by oak caps, cut to pattern, and each end of said cap securely fastened to posts with iron fastenings. Twenty-two inches above the top of this cap a girth of oak, 2″x4″, dressed four sides, will be inserted to hold the iron partition rods in place between horses.

All double stalls will have swing bars of oak in two pieces, the lower, 2″x12″x5′—4″, hung with iron screw rods, swivel joints, to the upper 2″x12″x8′—0.″ The latter will be hung to the manger at its front end, with a chain connection, and to the plates on top of stall posts at its rear end by ½″ iron rod, with chain and wagon break attachment at its lower end, so that it can be readily detached and dropped to the floor.

Stall plates on top of posts will be of pine, 2″x6″, doubled over all double stalls.

Stall posts will be of oak, 6″x6″x8′—0″, dressed on four sides, and corners chamfered. All posts set plumb and true, and containing a harness pin, turned from oak or ash.

Feed alley partitions will consist of three pieces, 1″x10″, common pine, surmounted by one piece, 2″x16″, dressed one side.

### DOORS.

Doors to be made in accordance with detail drawings. Carpenter to furnish lintels, 4″x8″, dressed top and one side, for all doors and windows; also rails for all sliding doors and hung doors in most substantial and workmanlike manner.

### WINDOWS.

All window frames and sash to be made according to details and set in accordance with plans, plumb and true.

### MANGERS.

The mangers will be built of oak, top and front 2″×12″, and thoroughly fastened and secured in plan.

### DOOR SILLS.

Door sills, with exception of three stone sills, will be of oak four inches thick, sixteen inches wide, and six inches longer than opening in brick wall.

The following is an itemized bill of the lumber used in the construction of this stable.

| | | | Inches. | Feet. | |
|---|---|---|---|---|---|
| | 1280 | pieces | 2×4, | 14 | |
| First floor joists | 160 | " | 2×4, | 10 | |
| First floor posts | 112 | " | 10×10, | 14 | |
| First floor posts | 2 | " | 10×12, | 14 | |
| First floor corbels | 112 | " | 10×12, | 4 | |
| First floor corbels | 2 | " | 10×12, | 12 | |
| Second story girders | 128 | " | 4×14, | 14 | |
| Second story girders | 80 | " | 6×14, | 20 | |
| Second story girders | 28 | " | 6×14, | 16 | |
| Second story girders | 4 | " | 4×14, | 12 | |
| Second story joists | 177 | " | 2×10, | 10 | |
| Second story joists | 1400 | " | 2×12, | 14 | |
| Second story posts | 28 | " | 6×6, | 7 | |
| Second story posts | 28 | " | 6×6, | 8 | |
| Second story posts | 54 | " | 6×6, | 9 | |
| Second story posts | 2 | " | 10×10, | 9 | |
| Second story corbels | 110 | " | 10×12, | 4 | |
| Second story corbels | 2 | " | 10×12, | 12 | |
| Roof girders | 126 | " | 3×12, | 14 | |
| Roof girders | 78 | " | 6×12, | 20 | |
| Roof girders | 2 | " | 6×16, | 30 | |
| Roof joists | 1400 | " | 2×10, | 14 | |
| Roof joists | 177 | " | 2×10, | 10 | |
| Air ducts, sides | 112 | " | 2×12, | 14 | |
| Air ducts, sides | 14 | " | 2×12, | 10 | |
| Air ducts, tops | 56 | " | 2×12, | 14 | |
| Air ducts, tops | 14 | " | 2×12, | 10 | |
| Air ducts, bottom | 56 | " | 2×10, | 14 | Dressed 2 edges |
| Air ducts, bottom | 14 | " | 2×10, | 10 | |
| Gutters, sides | 192 | " | 2×12, | 14 | |
| Gutters, bottoms | 96 | " | 2×5, | 14 | Dressed 2 edges |
| Stall partitions | 720 | " | 2×12, | 14 | Dressed 2 sides. |
| Partitions | 400 | " | 2×12, | 16 | Dressed 2 sides. |
| Feed alley partitions | 96 | " | 2×16, | 14 | |
| Feed alley partitions | 288 | " | 1×10, | 14 | |

| | | Inches. | Feet. | |
|---|---|---|---|---|
| Bridging | 700 pieces | 1½×3, | 10 | |
| Wall plates, etc. | 140 “ | 2×4, | 16 | |
| Lintels, windows | 25 “ | 4×8, | 16 | |
| Lintels, doors | 20 “ | 4×6, | 16 | |
| Stall caps | 220 “ | 2×6, | 14 | |
| Ventilators | 36 “ | 4×4, | 16 | Dressed 4 sides. |
| Ventilators | 100 “ | 1¼×1¾, | 14 | |
| Crown mouldings | 35 “ | 3 | 14 | |
| O. G. Battens | 500 “ | 2½ | 16′ | |
| Quarter round | 400 “ | 1½ | 10 | |
| Casing | 100 “ | 1⅛ | 16 | Dressed one side. |
| Cord ties | 245 “ | 2×14, | 4 | Dressed one Side. |
| Cord ties | 245 “ | 2×12, | 4 | Dressed one side. |
| Gutter strips | 192 “ | 1×2, | 14 | |
| Door bars | 16 | 3×6, | 8 | Dr'sed 4 sides 3rd clean. |
| Door bars | 25 “ | 3×6, | 16 | Dr'sed 4 sides 3rd clean. |
| Door bars boxes | 32 “ | 1×6, | 16 | Dr'sed 1 side 3rd clean. |
| First floor | 2″×10′, | 5000 pr | Bm. | |
| First floor | 2″×9′, | 37500 pr. | Bm. | |
| First floor | 2″×16′, | 16000 pr. | Bm. | |
| Second floor D & M C F | 1″×16′, | 30000 pr. | Bm. | |
| Second floor D & M C F | 1″×16′, | 40000 pr. | Bm. | |
| Roof C B S 1 side | 1″×16′, | 30000 pr. | Bm. | |

### Oak.

| | | Inches. | Feet. | |
|---|---|---|---|---|
| Stone posts | 360 pieces | 6×6, | 8 | Dressed to pattern. |
| Stone caps | 216 “ | 2×4, | 7 | Dr'sed 4 sides |
| Stone caps | 8 “ | 4×4, | 8 | Dressed to pattern. |
| Stone caps | 240 “ | 4×5, | 8 | Dressed to pattern. |
| Stone mangers | 216 “ | 2×12, | 14 | |
| Swing bars | 72 “ | 2×10, | 5⅓ | |
| Swing bars | 72 “ | 2×8, | 9 | |
| Door sills | 16 “ | 4×16, | 7½ | |
| Door sills | 2 “ | 4×16, | 14 | |
| Door sills | 2 “ | 4×16, | 10 | |

### MILL WORK.

| | | | | |
|---|---|---|---|---|
| 15 sash doors | 3½″ | double thick | 7′ 3″×10′ 8″ | Plan E. |
| 3 doors | 2½″ | “ | 4′ 3″×8′ 0″ | Plan G. |
| 5 doors | 2½″ | “ | 4′ 0″×8′ 0″ | Plan G. |

1 sash door .. 3½" double thick 10' 0"×12' 0" Plan C.
In one part.
1 sash door .. 3½" " 10' 0"×12' 0" Plan D.
1 sash door .. 3½" " 10' 3"×12' 6" Plan K.
In one part.
3 doors and frames with transom 2' 10"×8' Plan B.
7 doors and frames ........... 2' 10"×7'
2 sash doors 3½ double thick . 12' 6"×14¼' Plan M.
In one part, segment head.
17 window frames and sash, 32 lights 9"×14"
Segment head, square back.
50 window frames and sash, 16 lights 9"×14"
Segment head, square back.
2 mullein frames and sash, 32 lights 9"×14"
Segment head, square back.

### BILL OF IRON.

3300 partition rods, ⅝"×30"; 14 ventilator grates, 15"×24"; 288 pries gutter covers, 6"×56"; 72 sets swing bars complete; 288 hitching rings, 2" diameter; 288 staples for same, 3" long; 96 angle irons, size each 8"×⅜"; 384 wagon straps; 538 machine bolts, 16" long, 2" thread; 264 machine bolts, 12" long, 2" thread; 252 machine bolts, 10" long, 2" thread; 2108 cast iron washers, 3" diameter; 250 T anchors; 40 wall hitching rings; 68 window weights, 17 lbs.; 32 window weights, 7 lbs.; 216 window weights, 10 lbs.; 1600 lin. ft. strap iron, 1⅝" wide; 1000 lin. ft. strap iron, 1" wide.

### CAR HOUSES.

The general plan adopted for the car house, is not a matter of so much importance as that of the stable, and it will vary under different circumstances.

The following description of a car house adjoining the aforedescribed stable embodies my idea of such a building at that point.

The building faces south on Belden av., with a frontage of 74 ft., and west on Racine av. 192'-4". It is two stories high, of brick, and lighted from four sides. Pl. I is a ground plan.

It contains seven tracks on the first floor, with room for forty cars.

At the southeast corner a waiting room for passengers is provided, 10'x14'.

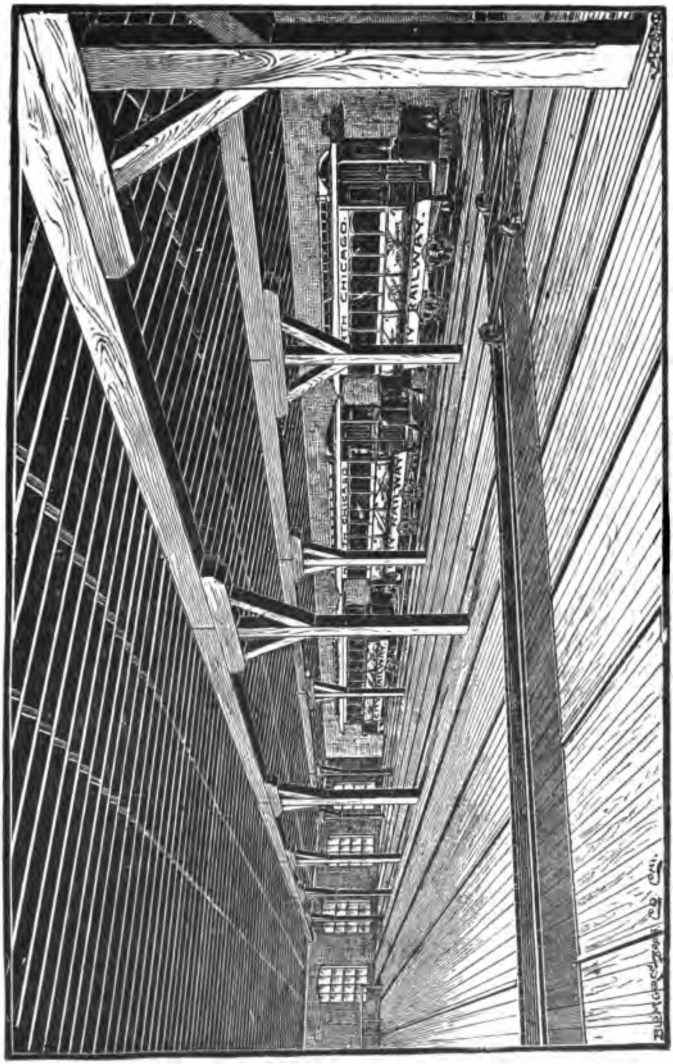


FIG. 62.

The cars enter from Racine av. through a door 86 feet from the front, and pass out through a door in Belden av., returning to Racine by a reverse curve.

The horses are brought from the stable and changed in the car house.

Along the wall, adjacent to the waiting room, twenty-four closets are provided with Yale locks. Each closet is used by a conductor and his driver, both having keys. Here they keep waterproofs, overshoes, etc., and do not, consequently, have to carry these articles upon their car.

The transfer table is located 94.75 feet from the front of the building. When it is put at either end, as is frequently the case, if it is desired to get out a certain car at the other end of the track, twice as much switching must be done to reach the car as by this location.

Figure No. 63 shows the transfer table, which is built so that the pit requires only four inches of depth, and horses can walk over it anywhere.

Beyond the transfer pit is located the wash room, which contains a stove to heat it in cold weather. Quite an essential matter in so cold a climate as that of Chicago. The floor is composed of asphalt, laid with an inclination to the centre of the room, where a catch basin is built, connecting with the sewer, and having a metal strainer on top to catch matter that might stop up the sewer. The walls were all coated with hot asphalt for a height of six feet. This room is 45′ deep by 14′ 6″ in depth In the rear of the wash room is located a brick oil room, 9′x14′, where all oils used about the building are stored.

Adjacent to the oil room is located the elevator, with platform 28′ 3″x7′ 8″. It is worked by hand.

Steps near the elevator lead to the second story, which is used to stow one set of cars, either open or close, depending upon the weather. It contains the same number of tracks as down stairs.

The total capacity of this building is eighty cars.

The specifications for mason and carpenter work vary so little from those of the stable, that they are not repeated.

There were 365 cubic yards of excavations; 480 sq. ft. of dimension stone; 4,600 cubic feet of rubble; 387 m. brick; 93 window sills; 1 door sill; 30 bond stones; 532 lin. ft. of coping, in mason contract.

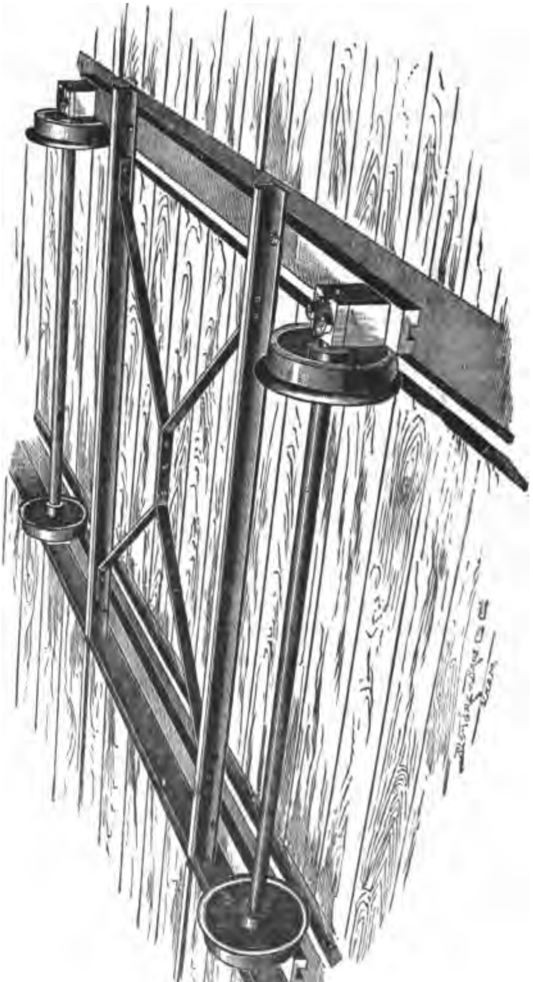


Fig. 63.

The following is the bill of lumber:

| | | In. In. Ft. In. | |
|---|---|---|---|
| First floor sleepers | 720 pcs. | 4× 4×14 0 | |
| First floor posts | 22 " | 10×10×12 0 | |
| First floor posts | 7 " | 10×14×12 0 | |
| First floor corbels | 22 " | 12×14× 4 0 | |
| First floor corbels | 7 " | 12×14×12 0 | |
| First floor braces | 14 " | 8×10× 6 0 | |
| Second floor girders | 56 " | 6×14×16 0 | |
| Second floor girders | 8 " | 6×16×30 0 | |
| Second floor joists | 432 " | 3×12×20 0 | |
| Second floor joists | 144 " | 3×12×14 0 | |
| Second floor posts | 14 " | 8× 8×12 0 | |
| Second floor posts | 8 " | 8× 8×10 4 | |
| Second floor posts | 5 " | 10×12×12 0 | |
| Second floor posts | 2 " | 10×12×14 0 | |
| Second floor corbels | 22 " | 12×14× 4 0 | |
| Second floor corbels | 7 " | 12×14×12 0 | |
| Roof, girders | 56 " | 6×14×16 0 | |
| Roof, girders | 8 " | 6×16×30 0 | |
| Roof, joists | 570 " | 2×12×20 0 | |
| Roof, joists | 190 " | 2×12×16 0 | |
| Transfer table | 6 " | 6×12×20 0 | |
| Transfer table | 6 " | 6×12×14 0 | |
| Common plank | | 1×16 | 27,000 ft. bm. |
| Dressed and matched | | 2× 6×16 | 35,000 ft. bm. |
| Com. bds. surfaced 1 side | | 1×16 | 14,000 ft. bm. |
| Partitions, s'faced 2 sides | 84 pcs. | 2×12×14 0 | |
| Wainscoting | | 1× 4×12 | 100 ft. bm. |
| Lintels | 8 pcs. | 4× 8× 5 4 | |
| Lintels | 35 " | 1× 8×16 0 | |
| Cord Ties | 28 " | 2×14×12 0 | |
| Bridging | | 1½× 3 | 6,000 lin. ft. |
| Wall plates, etc | 600 " | 2× 4×16 0 | |

### MILL WORK.

90 window frames and 1¾ sashes, 24 lights 9"×14" segment head, square back.

1 mullion frame and 1¾ sashes, 48 lights 9"×14" segment head, square back.

| | Ft. | In. Ft. In. |
|---|---|---|
| 1 sash door, 3½ D thick, in 2 parts, plan K | 10 | 3×12 6 |
| 1 " " " " 2 " " P | 12 | 3×13 1 |
| 1 " " " " 2 " " M | 14 | 3×12 0 |

| | | | | | |
|---|---|---|---|---|---|
| 2 | sash door, 3½ D thick, in 1 part, plan E.... | 7 | 3 × | 10 | 8 |
| 1 | " " " " " 2 " 18 lights. | 10 | 0 × | 12 | 6 |
| 1 | panel door and frame, with transom....... | 2 | 0 × | 7 | 6 |
| 2 | " " " " " " ....... | 2 | 10 × | 8 | 6 |
| 24 | closet doors. | | | | |

### BILL OF IRON WORK.

400 medium bolts, ½″ × 16″, thread 2″; 800 cast-iron washers, 3″ diameter; 368 window weights, 14 lbs. each; 4,760 lin. ft. track iron, ½″ × 1¾″.

This iron had holes, countersunk, each 16″, and was screwed on top of the floor.

The following is a bill of hardware for both buildings: 3 doz. upright pulleys; 44 double hanks sash cord; 3 doz. barn-door pulls; 11 pair 4″ × 4″ butts; 11 mortise locks; 6 pair heavy 12″ strap hinges; 4 pair heavy 10″ strap hinges; 1 doz. large size sash rollers; 24 Yale locks, with two keys each; 24 pair 2″ × 2″ butts; 5 doz. sash fasteners. Wrought-iron sheaves and track, 17 pair for 7 ft. door; 3 pair for 14 ft. door; 4 pair for 10 ft. door; 8 pair for 4 ft. door. One 2-horse power; one hay cutter; one 6-ton platform scale; one hand elevator, 27′ 3″ × 9′ 3″.

The total cost of both buildings was $42,936.99, which includes everything except the ground.

The first-story walls of both buildings are 16″ thick, second story, 12″ thick, and both have four-ply gravel roofs guaranteed for five years.

Fig. 64 is an exterior view, and Fig. 62 an interior view of this car-house.

### CHICAGO WEST DIVISION RAILWAY COMPANY'S STABLES.

Plate II represents ground plan, elevation, etc., of a stable built for the company named, of which Dewitt C. Cregier was General Superintendent, and Henry Raeder, architect.

The building may be briefly described as follows: It is 142 ft. wide by 256 ft. long, and two stories high. The footings of the foundations are of concrete throughout; they support walls above, built of roughly coursed rubble masonry. The stone walls reach to a height of eight inches above the established "inside grade." All the masonry above this point is brickwork. A feature of the building is the hollow wall of the first story. The first-story walls

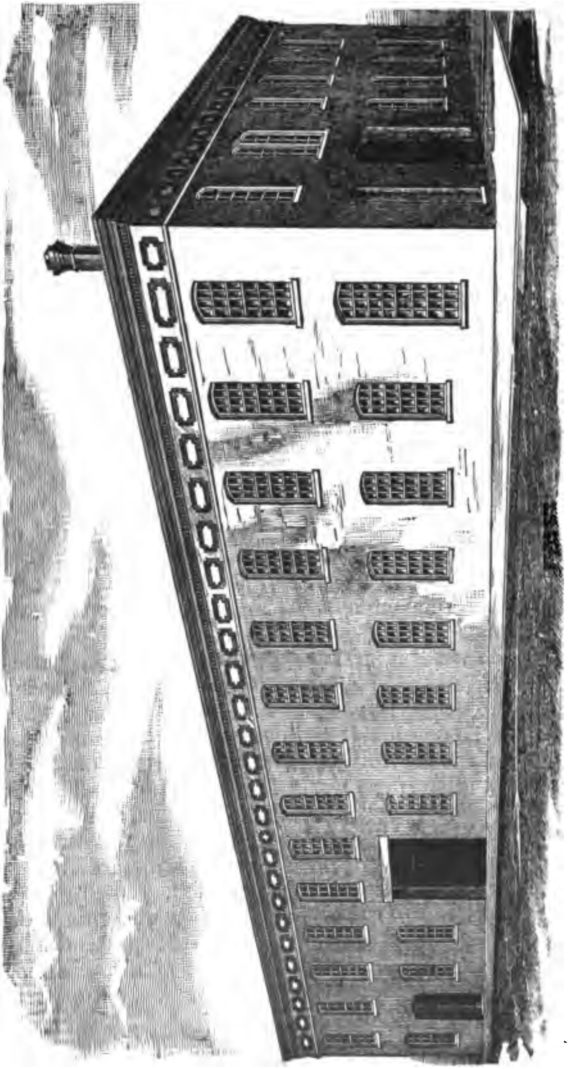


FIG. 64.

are built of two thicknesses—an outer one of eight inches, and an inner one of four inches, the two being separated by a two-inch air-space. The air-space answers the double purpose of keeping the stable warm in winter and cool in summer. There are fourteen rows of stalls separated at the front ends by a four-foot alley. The alleys are an important factor in the general scheme of ventilating the stables, as the fresh air is introduced through their floor. Underneath alley floor extends a box, made as air-tight as possible, connecting with the stable by means of holes in the alley floor. At the ends these boxes or air ducts connect with the outer air, and are provided with adjustable slides for controlling the air inlets. Ventilators in the ceiling of the stable, passing through the hay loft above and ending in a cupola with adjustable slides, operated from below, aided by air ducts in the brick walls, serve to carry off all foul air. The building is most thoroughly drained and sewered. The sub-soil water is lowered by means of open tile-drains surrounding the building on all sides. The sewerage system consists of a main through the centre of the building (connected with a catch-basin) and the necessary branches. The main pipe is ventilated at its upper end with a conductor spout, which also flushes the sewer at times of rain.

To this main pipe, V-shaped galvanized iron gutters, running along the rear ends of the stalls, are connected at their lowest points.

The V-shaped gutters are covered with oak plank, perforated here and there to pass the urine of the horses to the iron gutters below. All the stall floors slope toward the perforated oak plank. The floors are made impervious by laying tarred roofing felt between a floor lining and the floor proper. All waste pipes from fixtures are properly trapped. In short, the system of sewerage is carried out on strictly the same principles as is generally adopted for dwellings.

The following letters, with explanations, refer to Plate II: *V*, ventilators passing through the hay loft to the roof; *T*, trap doors for hoisting hay; *W T*, watering troughs; *A*, re-galvanized iron gutters; *B*, harness pins; *G*, inlet to ventilator ducts which run under floor; *C*, air space in first-story wall; *C′*, ventilator duct in wall.

# CHAPTER VI.

## MANAGEMENT OF STREET RAILWAYS.

The recent unsettled condition of the working classes, and consequent strikes, have not allowed the street railway managers to ignore this question, for trouble has arisen from the Atlantic to the Pacific, and from the North to the South.

As the conductors and drivers outnumber the other employees, the rules governing them are of most importance.

At the meeting of the American Street-Railway Association in St. Louis, October, 1885, Messrs. D. F. Longstreet and H. H. Littell, men of great experience, reported as follows on "Rules Governing Conductors and Drivers":

"Every street railway enterprise is dependent for its success upon its location and management; and the management is very largely dependent for its success upon the character and conduct of the conductors and drivers employed.

"These servants are the real representatives of the company before the public, and just in proportion as they are civil, polite and attentive, or the reverse, will the company obtain favor or disfavor with the public. They are also the trusted servants of the company for its revenue, and upon their watchfulness, fidelity and honesty, depends in a great measure the financial success of the enterprise.

"It is, therefore, of the greatest importance that good men should be selected for these positions, and equally important that good rules and regulations should be the guide of their conduct—such rules as will commend themselves to the judgment of reasonable men, and such as will conduce to the orderly conduct of the business, and the comfort, convenience and safety of the public; not only that portion which ride in the cars, but to the large number of pedestrians and teamsters.

"The streets are for the whole public, and while the street car is given by law the right of way, it should always be taken in the least objectionable manner, consistent with a proper conduct of the business.

"To one who has examined the rules in force in different sections of this vast country, it is obvious that no complete set of rules could be drafted which would meet the local requirements in all respects, and no attempt at such a compilation will be made by your committee; but its recommendation will be comfined to such general regulations as seem, from a careful survey of the subject, united with a long experience, to be applicable alike to all sections.

"The rules should be made as concise and as complete as possible; should be issued in convenient form to be carried in the pocket, and as discipline is one of the first essentials in the correct management of any body of men, they should be rigidly enforced. It should be made obligatory upon the men to carry the rules at all times when on duty.

"Ignorance of a rule should be no excuse for its violation, and willful or careless violation of their provisions should be made sufficient reason for discharge.

"Rules are properly divided into three classes, viz.:

"Discipline and Deportment;

"Comfort, Convenience, and Safety of the Public; and

"Collection of Fares.

"And we shall treat them in that order.

### "DISCIPLINE AND DEPORTMENT.

"The conductor should have charge of the car, and any disobedience of orders or infringement of the rules on the part of the driver should be reported.

"Starting behind time, loafing, or too fast driving; driving fast in going on or off turnouts, around curves or over railroad crossings; failure to answer the bell promptly or to stop the car properly; stopping the car across intersecting streets or on crosswalks; failure to keep a sharp lookout for passengers in main and cross streets; failure to signal promptly and accurately for passengers who get on at front end of the car; carelessness in driving; permitting unauthorized persons to drive; the use of profane, boisterous, or indecent language, or the use of intoxicating liquors, are all matters which a conductor should promptly report, to relieve himself from responsibility.

"As it is important that these employees should be neatly dressed, and as taste in the matter of dress differs so radically, it will be found advantageous to prescribe some neat uniform to be worn at all times when on duty. This will add not only to their general appearance but to their efficiency as well. A numbered badge should be worn at all times when on duty, and in a position to be plainly visible.

"They should treat each other with respect; be cautious and considerate, guarding themselves against envy, jealousy or other unfriendly feelings, refraining from all discreditable communications, except to those in authority, and upon such matters as it is made their duty to report. They should use no vulgar, profane, improper or ungentlemanly language, nor be guilty of any ungentlemanly conduct upon the car, to passengers or others, nor upon the company's premises. They should be civil, courteous, polite and attentive to the passengers at all times; be patient and answer any reasonable request of passengers, and direct strangers and others, when requested, to the nearest and safest way to their places of destination. They should abstain entirely from the use of intoxicating liquors, and should not frequent any place where the same are sold. They should not accept any fee, gift, treat, or entertainment of any kind from each other or from any employee of the company. They should attend punctually at the stable to take out their cars; remain with them at all times when *en route;* conform to the running time as nearly as possible, and always stop and start the car by the prescribed signal. The signal in most general use is one bell to stop, and two bells to start; and upon open cars it is customary and advisable to permit the use of a whistle for signals. The driver should signal the conductor by one bell for each passenger getting on at the front end after the first collection of fares. Other signals for putting on the rear brakes, for increasing speed, or to stop suddenly, are usually provided for, and will be found useful in an emergency. Every conductor should carry a watch, keep it exact with the office time, and start his car from each terminus promptly at the advertised time.

"The proper position for a conductor, when not otherwise engaged in the performance of his duties, is upon the rear platform, standing erect and on the watch for persons desiring to take the car. He should not engage his attention in reading, in unnecessary conversation with passengers, or in any way which would interfere with a correct and prompt performance of his duty.

"The driver should stand erect, with right hand on the brake-handle, controlling his horses with a taut rein, keeping a vigilant watch for persons who may desire to take the car, not only in the main, but in side streets, and at the same time with a careful eye to avoid collisions with pedestrains or vehicles, and should always speak pleasantly to teamsters when requesting them to move. They should both be ever on the alert to advance the company's interests and always ready to assist each other in any emergency. Cars, when heavily loaded, should not be stopped on steep grades, nor upon curves, except to avoid accidents. Jumping cars from the track should not, as a rule, be allowed ; on a single track it is better to change cars, or to run back to the nearest turnout.

"When necessary to eject a passenger for any cause, the aid of a police officer should be employed if possible. No more force than is absolutely necessary should at any time in such cases be used, and the names of reputable witnesses should be obtained. Suitable blanks should be furnished, to be filled out in case of accident, and upon which a full statement should be at once written and delivered promptly at the office. Articles found in the car should be promptly turned in at the office, with accompanying memorandum giving particulars.

### "SAFETY, COMFORT AND CONVENIENCE TO THE PUBLIC.

"The conductor comes in more direct contact with the public than the driver, and while many rules are applicable to him, the driver should at all times co-operate with the conductor as far as he can in carrying out the rules in their spirit and intent.

"The car should be kept clean and the lamps trimmed at all times, but it will in most instances be found desirable to provide special labor for this purpose and not make it a part of the duty of the driver and the conductor. Special assistance should be given to ladies, children and elderly or crippled persons getting in or out of a car. Seats should always be provided as far as possible. During cold and stormy weather the doors should be kept closed as much as possible. The rear platform should be kept as clear of passengers as possible, and children should never be allowed to ride upon either platform. Passengers should not be allowed to stand in the doorway nor upon the steps, when it is possible to avoid it. Passengers should be requested to alight at the rear end from the side nearer the walk. When a lady leaves the car care should be taken to observe that her dress is entirely clear from the platform and steps before giving the signal. Whenever the car is stopped at the request of any passenger, care should be taken to observe that every other person upon the car is in a position of safety before giving the signal, and passengers should be cautioned, and prevented as far as possible, from leaving a car while it is in motion. Expedition in receiving and landing passengers is always desirable, but never at a sacrifice of safety to individuals.

"Disorderly or otherwise obnoxious persons, whether or not under the influence of liquor, should not be allowed to ride upon a car, and any one perceptibly under the influence of liquor should never be permitted to ride upon the front platform.

"Smoking, the carrying of dogs and the distribution of handbills and peddling in the cars, are all matters which should be regulated by rule. The names of principal streets, hotels, depots, ferry landings, public squares and places of amusement, should be distinctly announced as the car reaches them. Provision baskets, or soiled or greasy bundles, should not be allowed inside a car, and not outside to the inconvenience of passengers or injury to car. Nothing should ever be hung upon the rear brake-handle. The car should always be stopped a reasonable distance before crossing a steam railroad track at grade, and the conductor, in the absence of a flagman, should go forward and give the signal to the driver to advance. If inside the car, the signal to go ahead should not be given without inquiring if all is right and receiving an affirmative answer. Passengers should be notified of any approaching danger, as an obstruction in the street.

"The liability to accidents on open cars is much greater than on box cars, because of so many places of entrance and exit, and consequently the very highest degree of care is necessary when running them.

### "COLLECTION OF FARES.

"There are few if any companies to-day which do not provide some sort of registering device to be used by the persons responsible for the collection of fares, and the rules governing the collection will depend upon the device used.

"As a rule the conductor should commence to collect fares at the front end and work to the rear. After fares have once been collected the driver should signal by one bell for every person getting upon the front platform, and all additional fares should be collected promptly as soon as passengers reach the place in the car to which they intend to go.

"Each fare should be registered at the exact place where it is taken, in the presence of the passenger paying it, and before another is collected. When fare-boxes are used the driver is also the conductor, and should not be permitted to handle the fares, but should see that every passenger's fare is deposited in the box.

"Having completed a set of rules to his satisfaction, no railroad manager should stop then; rules, no matter how good, will not enforce themselves, but the better the class of men employed, the easier it will be to enforce good rules.

"Drivers and conductors should be not only faithful but intelligent, for they are very often called upon to use discretion in matters which it is impossible to cover by the rules.

"As far as possible these employees should be selected from among the residents of the city or town in which the road is located, and such as are favorably known and indorsed by reputable citizens of the town. When first employed they should not be less than 21 or more than 40 years of age, energetic and of good habits. The pay should be sufficient to attract and hold such men, and their hours of labor should be fixed within the bounds of reason."

## RULES AND REGULATIONS

### FOR THE GOVERNMENT OF THE CONDUCTORS AND DRIVERS OF THE NORTH CHICAGO STREET RAILROAD CO.

(*Adopted August* 1, 1886.)

### DUTIES OF THE CONDUCTOR.

1. He is to be cleanly in his personal appearance, make use of no profane or improper language, and is to abstain from smoking, from the use of intoxicating drinks, and all ungentlemanly conduct or unnecessary conversation, when on duty or on the company's premises. He must not visit any saloon while on duty.

2. His position when on duty, and not collecting fares or seating passengers, will be on the rear platform. This position will the better enable him to keep a vigilant lookout for passengers in the opposite direction from that in which the car is moving on all corners and cross-streets. He will announce the names of principal streets as they are approached.

3. He will endeavor, as much as possible, to be on the rear platform when the car is passing street corners, especially those where he is likely to receive passsengers, and never to go inside of the car to collect fares as the car approaches a prominent cross-street, but immediately after the car has passed it. The car should be gently slackened as it approaches prominent cross-streets, to avoid collisions, and the better to enable the driver and conductor to see passengers upon them.

4. He is to stop the car in taking up and letting out passengers at the further crosswalk in going either way. He will endeavor to be on the rear platform, in all cases, when receiving or landing passengers, and not start his car until they are fairly received or landed; nor shall he allow elderly or infirm persons, ladies or children, to enter or leave the car while it is in motion, to get off or on the front platform. He will also, when passengers are getting off from the car, look and see that no car or team is approaching by which they might receive injury.

5. It his *especial* duty to provide seats for passengers as far as practicable, especially for ladies; and passengers must not be allowed to stand upon the rear platform or steps when there are seats or standing room inside the car, as they obstruct the passage of those who wish to enter or leave the car. The conductor should politely ask them to take seats or stand inside of the car.

6. He is to strike the bell to stop the car whenever any passenger makes it known that they wish to get off, notwithstanding they say to the contrary. He is to render all needful assistance to passengers having children, parcels, etc., and especially to ladies and elderly persons. He will not allow any drunken, filthy or indecent person in or upon the car, nor shall he permit any passenger to use any profane or obscene language, or be guilty of disorderly conduct; such persons should be ejected from the car, using no more force than is necessary. On no account, however, is a passenger

to be ejected while the car is in motion. In an ordinary case, or for a passenger refusing to pay fare, he is to call upon the nearest police officer. He is to be polite and courteous to all passengers under all circumstances. He is to be patient and answer any reasonable inquiry in reference to the road or company.

7. ACCIDENTS.—He will use the utmost care and caution to prevent accident of every kind to persons and property of the company. If any accident occurs, however slight, to persons or property, or to the property of the company, he must report the same as soon as possible to the superintendent or his assistant; also at the receiver's office for record; giving all the particulars and details, and as far as he is able, obtain the names and addresses of all witnesses to the accident. If persons are injured, however slightly, he must obtain their names and addresses in full, and render all assistance in his power.

8. He is to obey the driver's call—a tap of the bell—to collect fare from passengers on the front platform immediately, and pass on the outside of the car when it is crowded. He will render all needful assistance to the driver, which will be called for by a tap of the bell, when it may be necessary to hold the horses, or detach them from the car, and he is always to take the horses by the head when they are to be changed from one end of the car to the other.

9. He will not allow barrels, boxes, lumber, iron, or merchandise of a bulky nature to be put on the car; neither large dogs, nor baskets or bundles of meat inside the car; neither will he allow cards or showbills upon the cars without the permission of the superintendent or his assistant.

10. He is not to leave his car until he arrives at the end of his line, without permission of the superintendent or his assistant, nor to sit in his car when it is in motion, read the papers or any other matter that will interfere with the discharge of his duties.

11. He will report all defects in the road, cars, or horses, or any excavations at the side of the track, to the superintendent or at the receiver's office.

12. He must wear his badge at all times, when on duty, so that the number can be plainly seen by any one who may wish to know it.

13. He must be at the car house where the car is kept that he is to run, five minutes before the starting time. He

must start promptly from the terminus of his route on card time, always keeping his watch exact with the clock at the receiving office.

14. All conductors, when appointed, are to serve as extras, in number according to their turn and time of appointment, as follows: When a regular conductor is discharged, No. 1 extra is entitled to his car, and the remaining extras are provided in their regular order. Should any conductor not be on hand as required by Rule No. 13, he will be placed at the bottom of the extra list, and extra No. 1, if in attendance, will be entitled to the car; if extra No. 1 is not there, the next extra who shall report himself is to take the car, and extra No. 1 is to be placed at the bottom of the list. He is to assist in taking his car from the car house in the morning and putting it up at night.

15. He must be in full uniform while on duty. He must call out streets going south from Chicago avenue and going north from Kinzie street.

16. He will obey the directions of the assistant superintendent concerning his duties at the car house.

17. When wishing to report for duty, he will report to the assistant superintendent before five o'clock P. M.

18. He must stop his car at the farther crossing of any street, and in the middle of long blocks where sign is placed, for any passenger who wishes to enter or leave the car.

19. He must not stop at the first crossing of any intersection, on the bridges, or up grades, except to avoid an accident.

20. He will not be allowed to leave his car at the bridges, or at the end of the line, except in the performance of his duty. Going north, he will commence collecting fares immediately after crossing Lake street.

21. When going south he will stand by the rear brake of his car when crossing the viaduct and the bridge, until reaching South Water street, so that in case of an accident he can put on the brake; also, when going north down the grade, when not collecting fares.

22. He will not allow his car to stop at the north end of the bridge, but must go to the viaduct.

23. He will not allow any person to sit on the front dashboard under any circumstances.

24. He will not be allowed to sit on the dashboard south

of Division street. He will also keep the rear platform as clear as possible, always asking passengers to step inside.

25. He will not allow smoking on rear platform. He will politely ask smokers to take the front platform, and if they will not do so, will stop the car and have them step off.

26. He will not permit anything to be hung on the brake handle.

27. He must return all articles found in his car to the receiver's office immediately.

28. To prevent accidents and confusion, passengers should not be permitted to ring the bell. The conductor should observe them closely, and ascertain when they wish to get off.

29. All cars must go through on last trip, whether they have passengers or not. When running in, conductors will tell passengers that they are only going as far as the barn.

30. He will be held responsible to the company for all damages caused by neglect of duty or carelessness to the persons or property of others, or to the property of the company.

31. The driver and car will be under control of the conductor, subject to rules for driver.

32. It will be his duty to report to the superintendent or his assistants any driver who at any time attempts to diminish the receipts of the conductor by increasing the speed of the car, or by not promptly stopping for passengers, or for willfully neglecting to obey all proper signals, or who shall directly or indirectly harass any conductor, or be guilty of any other misconduct.

33. Each conductor will be required to have a copy of these rules and regulations with him at all times when on duty, and to make frequent study of them, and to be found familiar with them, and when he leaves the employ of the company will be expected to return them to the office.

34. If occasion requires any amendments or additions to the above rules and regulations at any time, such amendments or additions will be found posted on the various bulletin boards at the superintendent's or the receiver's office.

35. Any willful or careless violation of the above rules and regulations will be deemed sufficient cause for discharge.

36. IN REGARD TO BELL RINGING.—With a view to the prevention of accidents, all conductors employed by this company will observe the following rules; and any conductor

or driver who hereafter fails to obey them in every particular, will be immediately discharged from the service of the company.

*First.* Keep your hand off the bell strap, and place yourself as near the step as possible, ready with both hands to assist passengers on and off the car; do not pull the bell strap until the passenger is fully on the platform.

*Second.* Never pull the bell strap while passengers are getting off the car; wait until you see plainly that they have got safely off the car before you start again. Do not ring the bell from the inside unless the car is crowded so that you can not easily get out to the platform, in which case you will inquire in a loud voice if all is right and wait for an answer. It is a custom with conductors to neglect stopping their cars when gentlemen, especially young gentlemen, approach with the intention of getting on; this is wrong and will not be permitted. The positive orders are to stop your car as soon as you see persons coming to get on, and then wait until they are safely on the car before ringing to go ahead.

*Third.* Hereafter, in case your car comes to a stop at any crossing, curve or cross track, or being shut or cut off by teams, you will not allow your driver to start the car without being signaled by you. Conductors will not stop their cars for passengers to get on or off except at the farther crossing of any street and in the middle of long blocks where sign is placed; nevertheless the drivers must stop their cars always at the signal of the bell.

By proper observance of these rules accidents will be largely prevented. In case of any neglect, discharge will surely follow, and no excuses will be accepted.

### RULES FOR THE USE OF THE ALARM REGISTER.

1. When time to collect fare, conductors will commence at the forward end of the car, and fares must be collected in tickets or cash from every person over five years of age, except regular city police and firemen when in full uniform; otherwise collect fare from them.

2. The register must be used to cancel and record each and every fare collected by him. When one or more fares are paid he will record them on his register in the presence of such person, and record such fare or fares before another is taken up.

3. Employes of this company will ride on employe's badge. Any employe of this company failing to provide himself with employe's badge must pay fare or leave the car.

4. Complimentary books of tickets will be issued. These books will bear the name of the persons to whom they have been issued, and the conductor will be particular to see that they are used by no other persons. If presented by any one but him whose name it bears, the conductor will retain the book and return it to the office. The ticket must be detached and cancelled from this each time it is presented, and accounted for in the column of "*free.*"

5. Any failure on the part of conductor to have employes show their badges or collect fare from them, will be considered sufficient cause for dismissal from the service of this company.

6. He will on no account pass persons over the road because of their having been in the employ of this company.

7. He will keep his register and badge in a clean and bright condition.

8. Any conductor neglecting to set his register back to 0 at the end of each half trip will be discharged.

9. He will return his money and trip sheet to the satisfaction of the receiver. Any information which he may require in reference to his trip sheet, register, time and mode of settlement, will be furnished by the receiver.

10. Any failure on the part of conductor to fill out his trip sheet before returning it to the office, will be considered sufficient cause for dismissal from the service of this company.

11. When the conductor comes to the office on his last trip at night, he will return to the receiver his register and amount of his collections.

12. Should a conductor lose a register or injure one by tampering with it, he will be required to pay twenty-five dollars for it, also to pay for any damage to it by carelessness. He will not retain the register in his possession over one hour when off duty. If for any cause he be relieved from duty, either by order or by sickness, or of his own accord, he will at once turn in his register at the receiver's office. He will on no occasion lend his register or allow it out of his possession without the consent of the superintendent or his assistants.

13. The conductor will be required to account for the

number of fares indicated on the register, and will be required to pay the highest rate of fare for all that are short by the register.

14. If at any time the register does not work perfectly, the conductor must report it at the office immediately, *and procure a perfect* working register in exchange.

15. If the conductor runs but one trip and returns the amount of his collections and his trip sheet, the register must be returned also, so that the sheet and the register can be compared.

16. He will be required to have ten dollars in change at the close of each day's work as a bank for next day.

17. Any violation of the foregoing rules will be considered sufficient cause for prompt dismissal from the service of this company.

## DUTIES OF THE DRIVER.

1. He is to be cleanly in personal appearance, make use of no profane or obscene language, and is to abstain from smoking, from the use of intoxicating drinks, and from all improper conduct and unnecessary conversation with passengers. He must not visit any saloon while on duty.

2. He will see that his horses are properly harnessed before starting, to avoid stopping on the road. He is to start promptly on time when directed by the conductor, drive according to directions and conform to the running time, and avoid "loafing," or crowding with other cars.

3. He will not leave his car anywhere on the road, to get refreshment, or for any other purpose not actually necessary, without notifying the conductor. He is to keep a vigilant lookout for passengers on the corners and cross-streets, for carriages, cars, trucks, and especially pedestrians, to avoid accidents.

4. The proper position for a driver is to drive with as tight a rein as his team will permit of, and to hold his reins in his left or bridle hand, with his right hand on the brake, thus enabling him to have instant control over his team and car.

5. He must pay particular attention to brakeing-up his car when approaching a team or carriage on the track. He must be sure to brake-up in season to give the team or carriage sufficient room to get out of the track, if the wheels of the car should slide.

6. He is to drive slowly over all curves, switches and turnouts. At points where two tracks unite, he must drive with great caution. Racing is strictly forbidden on any part of the road. In case of a collision, at the junction of two tracks, the drivers of both cars will be discharged.

7. He will avoid running his car close up to the car in front when he is blocked up on the street; there should always be room for teams to pass between his horses and the car in front.

8. He will always stop his car whenever any person wishes to get off the front platform, notwithstanding what they may say to the contrary. He must notify passengers that it is a violation of the rules for them to enter or leave the car by the front platform.

9. Before starting his car, when the conductor is not on it, he will look and see if anyone is getting on or off. Particular attention is to be paid to the bell, and the brake is to be kept on until the conductor strikes the bell to start.

10. He will keep a good lookout for passengers on his route, and stop the car as soon as possible and proper, when asked or notified so to do.

11. He will at all times be courteous and polite to passengers, answering proper inquiries for information, and use especial care when passengers insist on getting on or off the car by the front platform.

12. He is to stop the car in taking and letting out passengers at the further cross-walk, in going either way, and not to start his car until notified to do so by the conductor. Whenever a passenger gets on the front platform, he must immediately ring the bell for the conductor to come for his fare.

13. Cars running in different directions should not stop abreast of each other, except at stations, or when transferring passengers. When cars are passing one another the drivers should slacken the speed of their horses, and gently put on the brake, to guard against running into persons who may be crossing the street, in the rear of either car.

14. In all places where the street is dug open for paving or other purposes, so as to endanger the safety of their horses, they must be detached from the car.

15. ACCIDENTS.—He will use the utmost care in controlling the team and car so as to prevent any kind of accident, either to his horse or car, or to other horses or teams

by collision, or to persons or passengers getting on or off the car, crossing the streets, or in any way liable to be injured by the horses or cars of the company.

16. In case of any accident, however slight, to persons or property, he is to note all the circumstances within his observation, and at once give the facts, and names of any witnesses he may obtain, to the conductor of the car.

17. He will be held responsible to the company for all damages caused by neglect of duty, or carelessness on his part to their property, or to the person or property of others, for which the company may be held responsible or liable.

18. Any driver who may be found wilfully or recklessly violating any of the above rules, will, upon sufficient proof, be immediately discharged from the service of the company.

19. Drivers are especially directed to make frequent and careful study of the above rules; and especially of those pertaining to accidents to persons and property; and to have a copy of the rules at all times in their possession.

20. Drivers when riding on the car when off duty, must show employe's badge to the conductor or pay fare. Badges can be had at the receiver's office.

21. Any driver refusing to show badge or pay fare when asked by the conductor will be discharged.

22. When wishing to report for duty, he will report to the assistant superintendent before five o'clock p. m.

23. He will not be allowed to drive faster than time gait on his last trip.

24. He will not be allowed to drive on the bridge after the bell stops ringing.

25. He will not be allowed to drive faster than a walk down grade off the bridge or viaduct.

26. Two cars must not meet at a switch; cars going in town will have right of way.

27. At the crossings of all railroads where steam locomotives are used he will stop his car fifty feet from it, to give his conductor an opportunity to go ahead of his horses, see if any danger exists, and in no case attempt to cross unless notified to do so by his conductor, who must be upon the track ahead of the horses at the time he gives such notice, and under no circumstances place his car in a position of danger. Any driver violating this rule will be discharged at once.

### SIGNALS.

One sound of the bell to stop the car.

Two sounds of the bell to start the car.

Three sounds of the bell to drive faster.

Four sounds of the bell to drive slower.

Four or more sounds of the bell to notify teams that are in the way.

### TO CONDUCTORS AND DRIVERS.

Conductors and drivers should bear in mind that a full compliance with the foregoing rules and regulations will be expected of them.

Particular attention is called to Rule No. 5 for conductors. It is a common thing to see the platform crowded when there are seats inside, and it is the cause of great annoyance to ladies entering and leaving the car, and no *gentlemen* will refuse, if politely asked, to observe so just a rule. See that your car is filled, and never allow a passenger to stand, if you can provide a seat. The conductor who is most successful in enforcing this rule will be duly appreciated by the company.

The careful observance of Rule No. 7 for conductors, is also very important. Injustice is often done to those who suffer, as well as to the company, when they are not fully apprised of all the circumstances of any accident that may happen. You can not be too particular about obtaining the names and residences of witnesses.

Finally, conductors should carefully regard Rule No. 3, for the use of the alarm register. The company will expect you to account for every person that rides upon your car, and that you will allow no one to pass without paying fare, except such as are entitled to.

F. L. THREEDY, *Superintendent.*

## IN CONCLUSION.

The aggregate yearly income accruing from the transportation of passengers upon the street railways of this country is a sum so vast that it cannot be comprehended by the human intellect; but great as it is, 'tis collected in driblets—five cents at a time! Truly an emphatic example that we should

"Think naught a trifle, though it mean appear:
Small sands, the mountains: moments make the year,
And trifles — Life."

The collection of fares, the employment of honest men, the safeguards put forth to deter the weak from becoming dishonest and to detect those who steal, are matters of so great moment that they are discussed at each succeeding convention of the American Street Railway Association.

To secure a satisfactory conductor the company must pay a fair salary.

Adam Smith wrote in his "Wealth of Nations:" "The proper performance of every service seems to require that its pay or recompense should be as exactly as possible proportioned to the nature of the service. If any service is very much underpaid, it is apt to suffer by the meanness and incapacity of the greater part of those who are employed in it. If it is very much overpaid it is apt to suffer, perhaps still more, by their idleness and negligence."

Each company will find it to be the part of wisdom to treat its employes fairly and justly, as recommended by the above committee. If the management of a road shall have established a reputation for harsh and unfair treatment of employes, good men will be loth to enter its service and strikes will be far more apt to occur upon slight provocation.

Allow the men time for meals, and do not require an unreasonable number of hours' service. Above all, when the services of a good, honest man have been secured, be not hasty in discharging him.

Upon the question of honesty of mankind in general, I believe the world has changed, and for the better, since Shakespere wrote, "Ay, sir; to be honest, as this world goes, is to be one man picked out of ten thousand."

Honesty is a matter of education, not natural to mankind. Other things being equal, the man who as a child was taught to tell the truth, to be honest and true, to do unto others as he would they should do unto him, is not likely to steal.

Montaigne, that profound student of human nature, wrote three hundred years ago:

"Plato reprehending a boy for playing at some childish game: 'Thou reprovest me,' said the boy, 'for a very little thing.' 'Custom,' replied Plato, 'is no little thing.'"

Our greatest vices derive their first propension from our more tender infancy; our principal education depends upon the nurse.

In employing a conductor, therefore, the superintendent should, so far as possible, ascertain something of his family and past life. Heredity and environment have a weighty influence in the formation of each human character.

Where many men are employed this information can be obtained only through "references;" for—"Men can be judged by those who know them, not only as they are represented by those who know them," wrote the grave Samuel Johnson. Yet an experienced observer can frequently judge accurately of the character of an applicant by a careful scrutiny of his countenance.

> "At a glance thou judgest well; years could add little to thy knowledge
> When honesty's open brow or the weasel face of cunning is before thee."

Having made your selection and employed an "honest man," lead him not into temptation! Throw safeguards about, so that if he wavers he may not fall. The experienced superintendent realizes the multitude of temptations that beset their conductors upon every hand. A little yeast leavens the bread! One dishonest employe debauches many.

Much more might well be written upon the important subject of street railways, but the organization of the American Street Railway Association, inaugurated by H. H. Littell and others, with its annual meeting, valuable papers by practical men, founded on experience gained by years of active service, the discussion that always follows the reading of said papers, and the publication of these proceedings fill a long felt want. I trust that the association will continue to grow as rapidly as in the past, until it shall include *every street railroad* among its members.

Two papers are now devoted exclusively to the street railroad interest, and the amount of available information is, therefore, now far greater than ever before.

# APPENDIX I.

## AMOUNT OF HORSE POWER USED IN PROPELLING STREET CARS.

A paper read before the Western Society of Engineers, Nov. 3, 1885.

By AUGUSTINE W. WRIGHT.

At the present time great interest is manifested by street railway companies regarding the question of the substitution of some motive power to propel their cars other than horse flesh. The various systems—electrical, cable, compressed air, Honigman, steam dummies, etc., etc., are prominently before the public, and each for itself claims, if not perfection, certainly that it is better than any other system.

It appears to me that great ignorance exists upon the part of the inventors and street railway companies themselves, as to the amount of power required to start a street car and to maintain it in motion, under average conditions. Following is an attempt towards a solution of this problem:

We will begin with Horse Power. Watt's experiments, made with large horses of the London Brewers, gave 33,000 pounds raised one foot high in one minute as the power exerted by an average horse, and this, as you all know, is the allowance in figuring engine power. This is on the assumption that a horse can exert a force of 150 lbs. over 20 miles per diem at the rate of 220 feet per minute or 2½ miles per hour, during 8 hours. But the horse's power is very variable at different speeds. Tredgold's experiments gave 125 lbs., Smeaton 100 lbs., Hatchette 128 lbs.; all 20 miles per diem at 2½ miles per hour. Gayffier fixed the power of a strong draught horse at 143 lbs., 22 miles per diem and 2¾ miles per hour, and an ordinary horse 121 lbs. for 25 miles per diem and 2½ miles per hour.

As the speed of a horse increases, his power of draught diminishes very rapidly, until at last he can move only his own weight.

The following table shows the results obtained by different authors, those of Tredgold being for 6 hours' daily labor and those of Wood for 10 hours;

| Velocity. Miles per Hour. | Tests of Draught According to | | |
|---|---|---|---|
| | Leslie. | Tredgold. | Wood. |
| 2 | 100 | 166 | 125 |
| 3 | 81 | 125 | 83 |
| 4 | 64 | 83 | 62 |
| 5 | 49 | 42 | 50 |
| 6 | 36 | | 42 |
| 7 | 25 | | 36 |
| 8 | 16 | | 31 |
| 9 | 9 | | 28 |
| 10 | 4 | | 25 |

From the above table it appears that, according to Wood, at 4 miles per hour, a horse can draw only half his load at 2 miles; at 8 miles, only a quarter, etc.

Sir John Macneil estimates it at 60 lbs. moved 8 miles per diem at same velocity (Gillespie). "Wood's Practical Treatise on Railroads" contains an interesting chapter on horse power. He made many experiments. He quotes an interesting memorial to the House of Commons, May 3, 1830, from the proprietors of various (33) stage coaches running out of Liverpool, employing 709 horses. These horses traveled an average distance of 13 miles daily, at a speed not exceeding 10 miles per hour, and the stock had to be renewed every *three years.*

Tredgold assigned 37 lbs. as the power that a horse should exert over a distance of 10 miles in a day at a velocity of 10 miles per hour, or one hour's work. This was founded upon his experiments on stage coach horses. They endured this service only three years.

The speed of North Chicago City Railway cars is 6 miles per hour, including stoppages, and the average time of service is reckoned at five years for each horse traveling upon selected cobble stone pavement. Before the cobble stone was adopted the average railway service was four years per horse. The chief street railways of the United States estimate the railroad life of their horses at from three to five years.

I made the following tests of the force required to start car 110 of the North Chicago City Railway Co., and to keep it in motion after it was under way, using a Fairbank's Dynamometer. The track has a grade of two-tenths of a foot per hundred. (This grade is up and down, changing say each 250 lin. ft., and is compensated, as the observations were taken upon up and down grades.) The track was not free from sand. Between Chicago avenue and North avenue, on Clark street, Division street and Clybourn avenue, 88 tests, with an average of 14.8 passengers, weighing (estimated at 140 lbs.), with car, 6,772 lbs. The force required to keep the car in motion at an average speed of five miles per hour, including stops, averaged 109.5 lbs., or per ton, 32.3 lbs. This is on an old, worn out, iron rail.

Between Chicago avenue and Madison street, on Clark. on new steel rails, 53 tests, with an average of 20.9 passengers, gave 59.8 lbs. as the force required to keep the car in motion. This is an average of 15.6 lbs. per ton. The car made 17 starts on this track, with an average of 18.7 passengers. Average force exerted to start, 426.5 lbs.; average per ton, 116.5 lbs. On the first mentioned track 30 tests, with an average of 18.1 passengers, gave an average force of 487 lbs. Average per ton, 134.6 lbs.

Recapitulated, the force exerted per ton was in pounds,
On good track, to start, 116.5, to keep in motion, 15.6,
" bad " " " 134.6, " " " " 32.3.

These tests indicate the great loss of power entailed by bad track, and also the great loss in starting; and the better the track, the greater the relative loss in starting! On the poor track 134.6 lbs. per ton was exerted to start, and and this is 4.1 times the force required to keep the car in motion. On good track, 116.5 lbs. was the force required to start, but this is *7.1* times the force required to keep the car in motion!

Upon the North Chicago City Railway the average weight of car and its load is 7,740 lbs., or, in short tons, 3.87. Passengers averaged at 140 lbs. Our track is now all good. The average force, therefore, exerted in propelling our car is $3.87 \times 15.6 = 60.372$ lbs. when the car is in motion, and $3.87 \times 116\ 5 = 450.855$ lbs. force to start. The horses average 137.97 minutes service per diem. One hundred and three tests, upon 17 different cars, open and close, on various lines, with different drivers, made by me in different days and hours, give the following average for the horses. Time consumed in stopping, during which no power is exerted by the horse, 13.22 minutes. Time from starting until average speed is reached, 7.88 minutes.

| | | | | |
|---|---|---|---|---|
| **Now, the horses average, as per above....** | **137.97** | **minutes** | **daily** | **service.** |
| **Deducting time they are not exerting force.** | **13.22** | " | " | " |
| **Leaves actual work....................** | **124 75** | " | " | " |
| **Of this power is exerted to maintain motion** | **116.87** | " | " | " |
| **And extra power is exerted during......** | **7.88** | " | " | " |

The horse power, therefore, exerted in propelling a North Chicago Railway car with its average load, by a team in its average day's work, is

$$\frac{450.855 \text{x} 311.5 \text{x} 7.88}{33000} = 33.53 \text{ H. P. starting;}$$

$$\frac{62.372 \text{x} 623 \text{x} 116.87}{33000} = 133.22 \text{ H. P. maintaining motion.}$$

Total, . . 166.75 H. P.

This is used during 137.97 minutes. Average per minute, 1.208 H. P. per team; or for each horse, .604 H. P.

Upon a poor track, my previously quoted experiments show that this power would be about doubled, or 2.4 H. P. would be used per average car. About one-fifth of the horse power is used in starting the car (20.1 per cent.) Mr. Angus Sinclair experimented upon the Third Avenue Elevated Railroad, New York, and estimated that the average pull on the draw bar was five times greater than it would have been if the motion of the train could have been continuous. See *National Car Builder*.

A. M. Wellington found by his experiments that the initial friction in starting trains of loaded cars was 5.47 times that required to keep them in motion at a speed of 10 to 15 miles per hour. See Trans. A. S. C. E., December, 1884.

Charles E. Emory, Ph.D., found 11.8 lbs. per ton of 2,000 lbs. to be the resistance on straight and level track in New York. This is less than my average, but his tests were probably made on a centre-bearing rail, the usual rail in New York, and this, we know, offers less resistance to progress, as the head is comparatively clear, while the step rail head upon which I experimented was *level with the adjoining outside pavement*, and consequently covered more or less with sand and dirt.

D. K. Clarke in his work on tramways, states that H. P. Holt found the resistance per gross ton, on straight, level track varied from 15 to 40 lbs.; Henry Hughes, 26 lbs.—often much more, occasionally less.; M. Tresca, 22.4 lbs. per ton. Subsequently M. Tresca removed two flanged wheels on one side of the car, and then found the resistance 15.25 lbs. Mr. Clark assumes 20 lbs. per ton, and says at times it is 40 lbs. per ton. "An average of 30 lbs. per ton may be taken for the calculation of the ordinary tractive force." In his second volume, he states: " The average resistance—30 lbs. per ton—already in the first volume adopted for calculation, may be readopted; although an occasional maximum of 60 lbs. per ton may be reached, and on the contrary a minimum of 15 lbs. per ton when the rails are wet and clean, straight and new."

Mr. Clarke's remarks refer to grooved rails, which offer greater resistance than the step rail.

Gen. Gilmore estimates this resistance at 16⅔ lbs. per short ton, with track in average condition, for United States.

Mr. C. B. Holmes, President and Superintendent of the Chicago City Railway, stated that his cable railway required for ordinary operation engines of 477 H. P.; of that it took 389 H. P. to move the cable and machinery; 88 H. P. (18½ per cent.) was used for the propulsion of 240 cars weighing 6,000 lbs. each and carrying each 5,000 lbs. of passengers. The average speed was 9 miles per hour, or 792 feet per minute. This statement would indicate that only $\frac{88}{240} = 367$ H. P. per car was required, while my experiments would give, as 3.87 (my average load) is to 5.5 (his average load) so is 1.208 H. P. (used by me) to 1.71 H. P. required.

There must have been some mistake in his test, for .367 H. P.=1211, foot pounds. As his speed is 792 feet per minute, the tractive force exerted would be only 15.29 lbs. for 5.5 tons—a resistance of less than 3 lbs. per ton (2.78 lbs.), which is impossible upon a step rail.

Our fellow member, D. J. Miller, M. E., while employed upon the above mentioned cable railway, made experiments upon the horse power used. He found that at an average speed of 6.85 miles per hour, or 602.8 feet per minute, 1 H. P. was required for each ton of cable and machinery and .2 of a horse power for each ton of car and its passeng For my average load of 3.87 tons, this would equal .774 H. P., instead of 1.2 H. P., as estimated by me. Mr. Miller's .2 H. P.=6,600 foot pounds. His average speed being 602.8 feet per minute, his resistance to traction could have been only 10.95 lbs., including starting the cars. This is

3.94 times the resistance found by Mr. Holmes, but nearly 30 per cent. less than my experiments would indicate. Mr. Miller, however, *assumed* the weight of passengers, having no count of their number, and must have over estimated the load, and experimented with the track unusually clean. My average of 15.6 lbs. per ton, agreeing so nearly with those of M. Tresca, 15.25, as above quoted, confirm my opinion that it can not be far wrong. While it is true that M. Tresca's experiment quoted was with only one flanged wheel upon each axle, yet that wheel traveled in a groove, and the resistance could not vary much from my two flanged wheels not in a groove. The car wheels in Chicago are 30 inches in diameter. The horses of the North Chicago Railway weigh about 1,100 lbs. each. The speed at which they travel upon the road averages 623 feet per minute or 7.08 miles per hour. Their average horse power developed being each .604 H. P., equals 19.932 foot pounds. Divided by 623, the distance per minute, gives 31 99 lbs. tractive force. Leslie's estimate at 7 miles per hour was 25 lbs. Wood's estimate was 36 lbs. at the same speed. Our horses work daily 2 hours, 17.97 minutes, but *seven* days in the week, unless prevented by some unforseen cause.

I have neglected extra resistance caused by curves, because our lines are chiefly tangents, and it is very difficult to measure the force exerted upon curves, for it varies greatly, between 400 and 1,000 lbs. upon the dynamometer with the same car and load. My tests were so unsatisfactory upon curves, that I have thought it best to omit them entirely. Then, too, the horse walks around the curve, and the lessened speed in a measure affects the increased resistance.

The greatest exertion of force upon a tangent during my dynamometer experiments occurred in starting a loaded car. It was 1,500 lbs., and per ton, 283.5 lbs. Passing through some slush, caused by snow thrown upon the track, it equaled 75.6 lbs. per ton.

In estimating for any independent motor to propel street cars upon the North Chicago Railway, I would take the maximum load and resistance. I have known of 120 passengers upon an open car. Averaging them at 140 lbs. each, equals 16,800 lbs.; car, 4,800 lbs.; total, 21,600 lbs., or 10.8 short tons; speed in starting, 0 to 623 feet per minute; average, 311.5; $\frac{10.8 \text{ tons x } 311.5 \text{ feet x } 283.5 \text{ lbs}}{33000}=28.9$ H.

P. required. A small portion of this power would be constantly employed, but it must be in reserve. With the electrical or cable system, no such allowance would be required, for the reason that this excess of power is only needed to *start* the car, and my experiments indicate that the car is starting only $\frac{1}{17}$ of the time, while it requires no power $\frac{1}{10}$ of the time. For each 17 cars upon a line, therefore, it would be necessary to furnish power to *start one* car and to maintain sixteen cars in motion, less the power when stationary, as it is not probable, nor is it necessary, that all should start at the same instant.

During my experiments the cars stopped upon an average, each, 1,178 lin. feet. We stop only at street intersections, or at the center of blocks more than 500 feet long.

The following returns are taken from the sixteenth annual report of the Massachusetts Board of Railroad Commissioners:

| NAME OF RAILROAD. | Number of horses owned. | Number of miles run. | Number of passengers carried. | Average No. Passengers per round trip. |
|---|---|---|---|---|
| Highland | 909 | 1,670,347 | 10,452,441 | 43 |
| Lynn & Boston | 608 | 1 052,296 | 6,364,009 | 50 |
| Metropolitan | 3,183 | 6,046,879 | 34,574,135 | 38 |
| Middlesex | 601 | 1,047,411 | 7,099,982 | 45 |
| South Boston | 857 | 1,470,261 | 9,706,299 | 41 |
| Total | 6,158 | 11,287,196 | 68,196,776 | 43.4 |

From the above, it appears that the stated average daily distance traveled by the above horses equals 10.04 miles, found by dividing total number of miles run by total number of horses, and this by 365, and multiplying by 2.

$$\frac{11.287.196 \times 2}{6158 \times 365} = 10.04.$$

The average number of passengers for these five railroads per round trip being 43.4, per single trip =21.7. Averaging them at 140 lbs. =3,038 lbs. Add weight of car, 4,800 lbs., =7,838 lbs., or 3.919 short tons, which is in excess of my average load of 3.87 tons.

It is fair to assume that these horses are worked to the best advantage, and that this is all that can be expected of a horse upon a tramway.

The stables of the North Chicago Railway are located at or near one end of each line. The horses are in excellent condition. Their mileage could not be increased, even if it was thought desirable, unless they were changed from car to car upon the road, and this would cause delay and inconvenience. They now make two round trips, and could not make more without adding fifty per cent. to the distance they now travel, or changing upon the road.

The foregoing calculations are made for the resistance upon a straight and level track. If the car has to pass up an inclination, the power required is increased.

The following table contains in the first column the rise in feet and tenths of a foot, in one hundred lineal feet. The second column, the resistance over and above that of a level track, caused by the rise in the first column, and the third column contains the resistance of a level track, assuming that this resistance upon a straight and level track is 15.6 pounds. The fourth column contains the total resistance of each grade.

| RAISE IN 100 LINEAL FEET, HORIZONTAL. | Resistance due to grade alone. Pounds. | Resistance on straight and level track. Pounds. | Total resistance. Pounds. |
|---|---|---|---|
| 0.1 | 2.0 | 15.6 | 17.6 |
| 0.2 | 4.0 | 15.6 | 19.6 |
| 0.3 | 6.0 | 15.6 | 21.6 |
| 0.4 | 8.0 | 15.6 | 23.6 |
| 0.5 | 10.0 | 15.6 | 25.6 |
| 0.6 | 12.0 | 15.6 | 27.6 |
| 0.7 | 14.0 | 15.6 | 29.6 |
| 0.8 | 16.0 | 15.6 | 31.6 |
| 0.9 | 18.0 | 15.6 | 33.6 |
| 1.0 | 20.0 | 15.6 | 35.6 |
| 2.0 | 40.0 | 15.6 | 55.6 |
| 3.0 | 60.0 | 15.6 | 75.6 |
| 4.0 | 80.0 | 15.6 | 95.6 |
| 5.0 | 100.0 | 15.6 | 115.6 |
| 6.0 | 120.0 | 15.6 | 135.6 |
| 7.0 | 140.0 | 15.6 | 155.6 |
| 8.0 | 160.0 | 15.6 | 175.6 |
| 9.0 | 180.0 | 15.6 | 195.6 |
| 10.0 | 200.0 | 15.6 | 215.6 |

The foregoing table contains the resistance upon various grades; but when animal power is used to propel a car, the power that the horse can himself exert is lessened with the increasing grade, so that at a certain inclination the horse could only propel himself.

Upon grades, therefore, the force required to propel each ton of car and its load is *increased* at the rate shown in column two of the above table, and the ability of the horse to draw the load is *decreased.* If we assume that the horse weighs 1,000 lbs., and exerts a force equal to 100 lbs. upon a level—

Upon a grade of one foot in one hundred he can exert a force of 90 lbs.
" " " " two feet " " " " " " 80 "
" " " " three " " " " " " " 70 "
" " " " four " " " " " " " 60 "
" " " " five " " " " " " " 50 "
" " " " six " " " " " " " 40 "
" " " " seven " " " " " " " 30 "
" " " " eight " " " " " " " 20 "
" " " " nine " " " " " " " 10 "
" " " " ten " " " " " " " 0 "

Therefore, if he weighs 1,000 lbs., and can exert a force of 100 lbs. upon a level, in surmounting a grade of 10 feet in 100 feet horizontal, all his strength would be exerted to propel himself, and he could not draw any load.

The assumption upon which the last table is figured, you will notice, is that the horse weighs 1,000 lbs. and exerts a force of 100 lbs. This force is exhausted in raising his own weight up a grade of ten feet in one hundred feet horizontal.

The estimates, already quoted, place his power at from one hundred to one hundred and fifty pounds, at a speed of two and a half miles per hour.

For a *short* distance he is capable of exerting several times this force.

My own experiments gave 1,530.9 pounds.

Cresy estimates it at from 300 to 525 kilogrammes, or 661.39 to 1,643.56 pounds. Haswell estimates it at 1,540 pounds.

It may, therefore, be safely estimated that for a short "spurt" at slow speed, he can exert *ten times* the force that he could exert during ten hours, at a speed of two and a half miles per hour.

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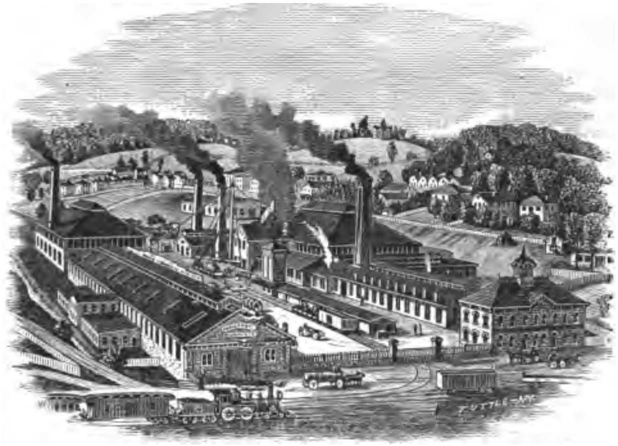

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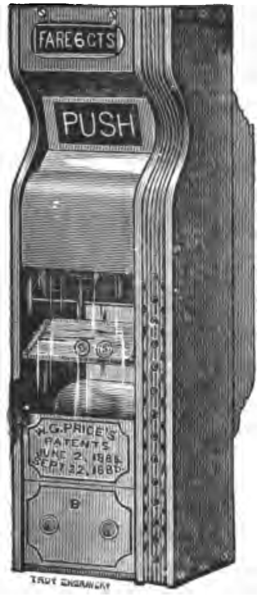

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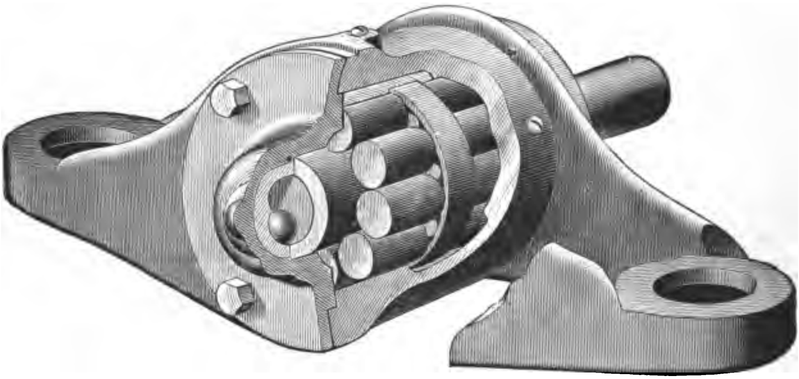

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